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Airborne Asbestos Fiber Concentration in Buildings: Surveys Carried Out in Latium (Central Italy)

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Abstract: In Italy, use and production of asbestos and asbestos-containing materials (ACMs) were banned in 1992, however, the risk of exposure to asbestos still exists, because most ACMs are located in industrial and public buildings. A total of 111 Italian buildings with friable and non-friable ACMs were surveyed; 500 air samples were collected in the areas where contamination might have occurred. Airborne asbestos fiber concentration calculated from air samples was averaged for each building. Statistical analysis of the data showed no significant differences between the mean concentration measured in buildings with friable and non-friable ACMs ($p = 0.258$). The concentration values were below 2 f/L, the value stated by Italian regulation to ensure that the area is safe to reoccupy after asbestos removal. Samples of settled dust were also collected. The presence of asbestos fibers in the dust showed the occurrence of a release of asbestos from the material. Although the airborne asbestos fiber concentrations measured were low, current Italian regulation requires an asbestos management program. The Public Institution to which the authors of this work belong encourages asbestos removal as the preferred abatement method, in line with the asbestos-free future approach proposed by the European Commission.

Keywords: asbestos-containing materials (ACMs); non-friable ACMs; friable ACMs; SEM-EDS analysis; buildings; public offices; airborne asbestos fibers

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1. Introduction

Its high technical performances ensured that asbestos was widely used in Italy for building and industrial applications until the 1980s. Asbestos was combined with several matrices to obtain so-called asbestos-containing materials (ACMs). The main worldwide use of asbestos was in combination with cement to make asbestos–cement products such as pipelines and flat and corrugated sheets. Asbestos was also used in asphalt and vinyl-based flooring, insulating products for pipes and boilers, roofing felts, special textiles, spray composition fireproofing products and electrical insulations.

In Italy until 1986, both chrysotile and amphibole asbestos were used in ACMs. Subsequently, due to the high health risk associated with the use of amphiboles [1], the production of asbestos cement sheets used only chrysotile.

The use and production of asbestos and ACMs were finally banned in 1992 [2], yet the risk of asbestos exposure still exists because most ACMs have not been removed. Although some 30 years have passed since the ban came into effect, they continue to be present in industrial environments and in public buildings.

The presence of asbestos in a building does not necessarily imply a health risk to occupants: when ACM is in good condition and cannot be damaged, it does not give rise to airborne asbestos fibers and exposure is unlikely. In well-maintained buildings containing asbestos, a mean fiber level of about 0.5 f/L has been reported, a value comparable to outdoor air concentrations [3].

On the contrary, when ACM inside a building can be damaged, asbestos fibers can be released into the air, posing a potential health risk to occupants.

ACMs are generally divided into friable and non-friable materials. ACMs that can be crumbled or reduced to powder by hand pressure, as defined by U.S. Environmental Protection Agency (EPA), are classified as friable materials [4]. They can contain up to 95 wt % asbestos and, if disturbed, they can be dangerous because they can very easily release fibers into environment. Friable ACMs in buildings can be found sprayed on ceilings, walls and other surfaces or as insulation on pipes, boilers, tanks, ducts and other systems [5].

Non-friable ACMs are typically building materials with an asbestos content of up to 15 wt %. In these materials a cement or polymeric matrix tightly embeds the asbestos fibers. They can only release asbestos fibers when sawn or scratched by mechanical tools. Examples of applications in building materials are roofing and floor tiles [5].

Several studies in the literature [6–10] show that mean airborne fiber concentrations measured inside buildings are low. The mean concentration within buildings is not substantially affected by repair/maintenance activities or falling or dislodging of ACM [11]. In addition, neither the condition of in-place ACM nor the accessibility of ACM is correlated with airborne asbestos concentrations [8].

Low indoor exposures to asbestos in non-occupational settings are currently of great scientific interest to better understand the dose–response relationships.

According to Italian law [12], safety actions must always be taken when ACMs are found, depending on the conditions of ACMs and the possibility of access to the area where they are present. If the ACMs are in good condition and not in danger of being damaged, they can be left in place because they do not give rise to airborne asbestos fibers; however, control measures must be planned to detect any release of asbestos fibers into the air in a timely manner and take action to restore safer conditions for occupants. If ACMs within the building are in good condition but easily accessible, a potential health risk to occupants exists because materials can be damaged, due to repair, renovation or vandalism processes, and fibers can be released into air. Specific preventive actions are necessary to reduce possible future exposure, and a periodic monitoring to control the airborne fiber level must be carried out.

Finally, if the ACMs are severely damaged or deteriorated, appropriate abatement actions must be taken based on the extent of damage to the ACMs. The abatement methods include asbestos removal, encapsulation and enclosure [12].

Removal is the most expensive method, but it is the only one that permanently solves the problem of possible airborne dispersion of asbestos fibers. However, removal activities must be carried out in compliance with all recommendations. In fact, if activities are performed improperly, high levels of exposure could occur that persist for a long time after asbestos removal [13] and that could result in dangerous occupational exposure for workers involved in ACMs removal activities [14].

Encapsulation involves applying a sealing coating to asbestos that prevents the fibers from dispersing into the air.

Enclosure involves a sealing barrier separating the asbestos from the occupied areas of the building. Enclosure should be completely airtight and is best used only when access to electrical, plumbing or ventilation services is not required. One disadvantage is the increased weight due to the insulation material, which, may tear off the enclosure from the substrate.

Enclosure and encapsulation require periodic inspections to monitor the condition of ACMs.

When asbestos fibers are released from ACMs they may remain in the air for some time and later fall to the surface and generate dust. The resuspension of fibers into air is highly variable depending on activities that disturb the dust.

At present, for indoor air quality, Italian regulation states a maximum limit value of 2 f/L of asbestos measured by scanning electron microscopy (SEM) to ensure that the area is safe to reoccupy after asbestos removal [12].

A review of asbestos legislation by the European Commission is underway to better protect people and the environment from asbestos and ensure an asbestos-free future.

Regarding buildings, asbestos information will be improved through screening and registration of ACMs to introduce digital building logbooks for better sharing and use of building-related data, from design to construction and demolition.

The aim of this work is to collect data from our surveys carried out from 1992 to 2014 in buildings with the presence of ACMs in order to relate airborne asbestos fiber concentrations to: the different types of ACMs (friable and non-friable), state of preservation of the ACMs and effectiveness of any abatement systems in place.

2. Materials and Methods

After the Italian law on banning asbestos and ACMs came into effect, our Institute carried out air samplings in 111 buildings with ACMs in Latium (Central Italy) from 1992 to 2014 to assess the risk of asbestos exposure to occupants.

A total of 85 were public buildings, in 80 of which there were non-friable ACMs and in 5 friable ACMs [15,16]. The other 26 buildings were 6 farms, 2 mechanical workshops, 7 storage warehouses and 11 industrial sites, 7 of which were non-operating. Only non-friable ACMs were found in all 26 of these buildings.

Most of the buildings investigated were built before 1980, during the peak years of asbestos production and use. In those years, chrysotile, amosite and crocidolite were widely used in asbestos cement products in Italian buildings. After 1986, chrysotile asbestos was the most commonly used form of asbestos in roofing due to restrictions on the marketing and use of crocidolite and crocidolite-containing products [1].

The first step of the surveys was visual inspection to identify the presence of materials that might contain asbestos. Inspection and identification of ACMs were conducted according to the criteria established by the Italian Ministerial Decree of 1994 [12]. During the visual inspection it was important to assess the condition of ACMs, their accessibility, and their physical properties, of which friability is certainly the most important.

During the site inspection, representative bulk samples of material were collected to check for the presence of asbestos. Moreover, a photographic documentation of each site was acquired. All samples were analyzed by stereomicroscope (LEICA M205C), phase contrast optical microscope (PCOM, LEICA), and scanning electron microscope (SEM, LEO 440) equipped with energy-dispersive X-ray analysis (EDS, Oxford Instrument INCA).

2.1. Buildings with Friable ACMs

Sprayed asbestos used as fire and thermal-acoustic insulation was present in 5 buildings (Table 1). All sprayed coatings are classified as highly friable materials and may contain up to 85 wt % asbestos [12].

Table 1. Type of friable ACM present in each building, composition of asbestos-containing mixture and abatement method used.

Building ID	ACM Type	Composition	Encapsulation	Enclosure
A	Sprayed on ceiling	Amosite and gypsum	No	Yes
B	plaster	Amosite and gypsum	No	No
C	plaster	Amosite and gypsum	No	No
D	Sprayed on ceiling	Chrysotile and vermiculite	Yes	No
E	Sprayed on ceiling	Chrysotile and vermiculite	Yes	No

Building A was a large machine shop in which there was an overhead crane running along two walls to transport materials. Its load-bearing structures showed a mixture of sprayed amosite and gypsum (Figure 1a) as insulation. The friable ACM was covered by a perforated metal ceiling. Between the ACM and the metal ceiling were sheets interposed. This solution could be considered an enclosure remediation, although it was not a completely airtight sealing barrier (Figure 1b).

(**a**) (**b**)

Figure 1. (**a**) Asbestos sprayed on load-bearing structures of a building. (**b**) Under normal use conditions, the friable ACM was covered by metal suspended ceiling.

B was a 3 floor office building. Its ground floor was used for handling printing material and had plaster with amosite. C was a 5 floor clothing store. One room on the first floor was used as clothing storage and had plaster with amosite. No asbestos abatement measure was taken.

Buildings D and E, which were used as department store warehouses, were insulated with a mixture composed of chrysotile and vermiculite. Both buildings had encapsulated ACM as an abatement method to reduce the possible airborne dispersion of chrysotile fibers. The encapsulant used was a coating material consisting of water-based elastomeric resins. In areas that had severe damage or deterioration, encapsulation of the ACMs was done with coating and penetrating encapsulants that provided a hardshell coating.

Encapsulation and enclosure require periodic inspections to monitor the condition of the ACMs. Thus, from 1992 to 1999 (when the asbestos was removed), two six-monthly samplings were conducted. In addition, other sampling was conducted in case of damage due to maintenance operations or vandalism.

2.2. Buildings with Non-Friable ACMs

Non-friable ACMs were found in 80 public offices and 26 buildings where agricultural, industrial, and machining activities were taking place.

The materials within these two categories of buildings were subjected to different mechanical stresses. ACMs within the public offices were little disturbed during normal work activities and were unlikely to be damaged. In the other 26 buildings, the use of processing equipment could cause high stresses in ACMs promoting the release of asbestos fibers.

Most of the public buildings had floors covered with vinyl asbestos tiles and asbestos cement panels used as partitions and ceilings. Analysis of bulk samples, carried out during a previous investigation [16] by phase-contrast microscopy (PCM) and scanning electron microscopy (SEM) equipped with energy-dispersive X-ray (EDS) analysis, showed the presence of only chrysotile fibers in the vinyl–asbestos tiles. Asbestos–cement products contained chrysotile and amphiboles such as amosite and crocidolite. Finally, asbestos–cement products containing chrysotile and crocidolite were also present on the exterior parts of some buildings, such as roofing and facades.

Although many ACMs were found in good condition, some were damaged. Figure 2 shows a damaged vinyl–asbestos floor, from which asbestos fibers could be released into the air. In some areas of the floor, the tiles were removed, leaving exposed a layer of black bitumastic adhesive that might itself contain asbestos.

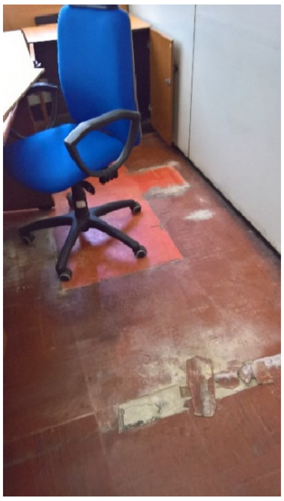


Figure 2. Example of damaged vinyl–asbestos floor tiles in office building.

2.3. Air Samples

At present, for indoor air quality, the Italian regulation [12] states a limit value of 2 f/l of asbestos to ensure that the area is safe to reoccupy after asbestos removal. According to this regulation, the number of samples depends on the surface of the area, and counting should be done by electron microscopy.

Five hundred air samples were collected in areas where contamination might have occurred: 195 in buildings with friable ACMs and 305 in buildings where non-friable ACMs were present. Air samples were collected on polycarbonate membranes (pore size 0.8 μm) using constant-flow pumps with an air flow rate of 7–10 L/min for about 6 h. Open-faced field monitor cassettes with conductive plastic cowl were used as filter holders. One quarter of each membrane was mounted on an aluminium stub, coated with a thin layer of gold and analysed by scanning electron microscopy (SEM—LEO S 440, LEO, Oberkochen, Germany) equipped with energy-dispersive X-ray analysis (EDS—LINK AN 10000, Oxford, UK). All fibers with length greater than 5 μm, width less than 3 μm and a length-to-width ratio (aspect ratio) greater than 3:1 were counted. Fibers that meet these criteria are classified as respirable fibers [17].

The concentration of airborne asbestos fibers was calculated by the following equation [12]:

$$C = \frac{(n \times \pi \times d^2)}{(4 \times N \times A \times V)}$$

where:

- n is the number of fibers counted
- d is the effective filter diameter in m
- N is the number of fields examined
- A is the area of a field in m^2
- V is the sampling volume in m^3.

2.4. Dust Samples

Settled dust provides information about past exposure to asbestos fibers in the air, unlike air samples that measure current conditions. Therefore, in all 111 buildings, samples of settled dust were collected by adhesive tape in areas not easily accessible for cleaning and were analyzed by SEM-EDS to identify asbestos fibers observed.

2.5. Statistical Analysis

Airborne asbestos fiber concentrations calculated from air samples were averaged for each building. The mean concentrations measured in buildings with friable and non-friable ACM were compared by applying the Kruskal–Wallis One Way Analysis of Variance on Ranks test [18] to assess the statistical significance. For data evaluation purposes, all samples with no asbestos fibers counted were treated as 0 f/L [19].

3. Results

3.1. Buildings in Which Friable ACMs Were Present

Airborne asbestos fibers were detected in all buildings where friable ACMs were present. Table 2 shows for each building with friable ACMs the number of air samples taken, sampling time, mean airborne asbestos fiber concentration, lower fiducial limit (LFL), upper fiducial limit (UFL) and maximum concentration.

Table 2. Mean airborne asbestos fiber concentration measured in buildings with friable ACMs. LFL, UFL and maximum concentration measured are also shown.

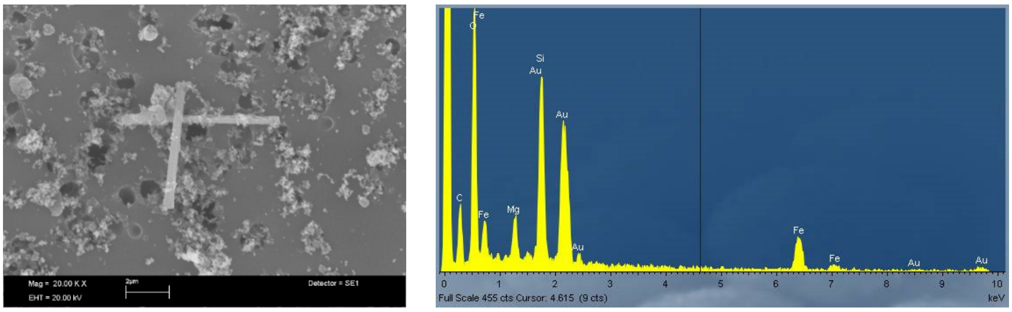
Building ID	Numbers of Air Samples	Sampling Time (min)	Mean Concentration (f/L)	LFL (f/L)	UFL (f/L)	Maximum Concentration (f/L)
A	104	250–340	0.8	0.4	1.6	1.8
B	13	250–340	0.5	0.2	1.2	1.3
C	3	250–340	0.5	0.2	1.2	1.0
D	55	250–340	0.6	0.2	1.4	0.8
E	20	250–340	0.5	0.2	1.2	1.4

In all five buildings both mean and maximum concentrations were below 2 f/L (the limit value set by Italian regulation for indoor air quality [12]). Only in building A did the maximum concentration approach the limit value.

Notably, despite the ACM enclosure, the highest maximum fiber concentration (1.8 f/L) was measured in building A, where the presence of an overhead crane (Figure 3) likely stressed the ACM with continuous vibrations that caused fiber dispersion.

Figure 3. Overhead crane present in building A. The figure shows two operators on lifting platform collecting samples of dust settled on the overhead crane.

SEM-EDS analysis performed on the air samples confirmed the presence of airborne fibers of the same type as the asbestos present in the ACMs (Figure 4).



(**a**) (**b**)

Figure 4. SEM image of airborne amosite fibers collected in building A on polycarbonate filter (**a**) and related EDS spectrum (**b**).

The maximum concentration of asbestos fibers in the air reached more than 1 f/L in the two buildings, B and C, where asbestos plaster was present and no abatement measures had been taken.

Such concentrations were also reached when the friable ACMs were encapsulated (buildings D and E) and small cracks had formed in the insulation material. After detection and repair of damage to the encapsulant, the airborne asbestos fiber concentration was below the detection limit, corresponding to 0.4 f/L for a filter reading area of 1 mm^2 and a sampled air volume of 3000 L. This value represents the limit below which, for a Poisson distribution, with 95% probability, the true concentration is found when no fiber is detected during SEM analysis [20].

3.2. Buildings in Which Non-Friable ACMs Were Present

In public office buildings with non-friable ACMs, 198 air samples were collected and 87% of the measured airborne asbestos fiber concentrations were below the detection limit. In 11% of the measurements, airborne asbestos concentrations were above 0.4 f/L and below 2 f/L. Finally, 2% of the measurements showed concentrations above 2 f/L. The air samples having the highest concentrations came from one building in which ACMs were highly deteriorated.

The results for public office buildings with non-friable ACMs are shown in Figure 5.

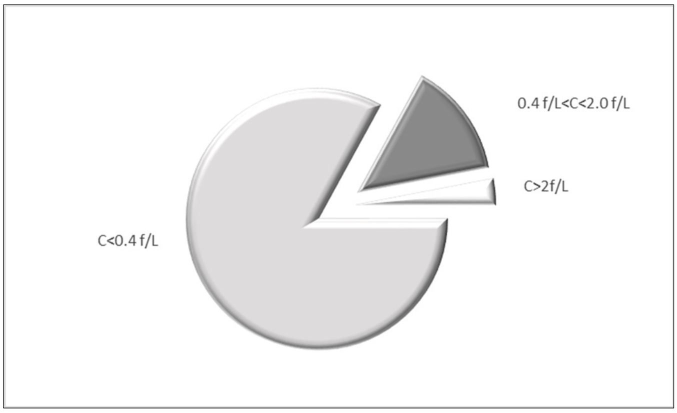
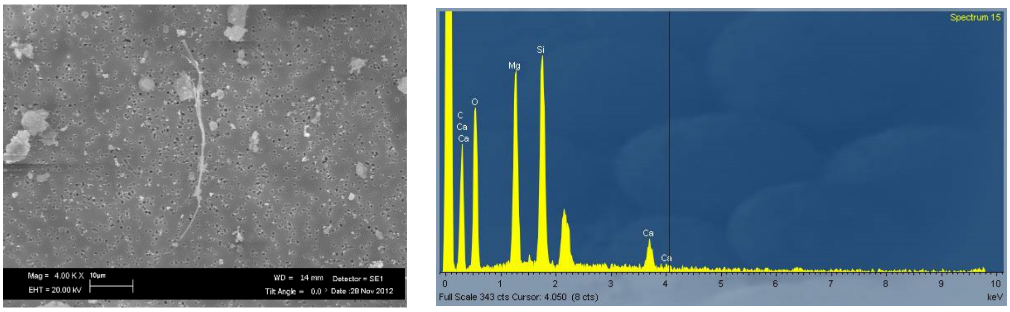


Figure 5. Maximum concentration of airborne asbestos fibers measured in public buildings with non-friable ACMs.

SEM-EDS analysis showed that chrysotile fibers were present in a few air samples (Figure 6).



(**a**) (**b**)

Figure 6. SEM image of airborne chrysotile fibers collected in a building with non-friable ACMs on polycarbonate filter (**a**) and related EDS spectrum (**b**).

In Table 3, public buildings were grouped according to the type of ACM detected. Mean airborne asbestos fiber concentration, LFL and UFL values, and maximum measured concentrations were also shown for each type.

Table 3. Mean airborne asbestos fiber concentration measured in public buildings with non-friable ACMs. LFL, UFL and maximum concentration measured are also shown.

ACM Type (Asbestos)	Number of Buildings	Air Samples	Sampling Time (min)	Mean Concentration (f/L)	LFL (f/L)	UFL (f/L)	Maximum Concentration (f/L)
Vinyl asbestos (chrysotile)	16	35	250–340	<0.4		0.4	0.4
Vinyl asbestos (chrysotile) + Cement asbestos (chrysotile, crocidolite)	29	72	250-340	0.1	0.0	0.6	0.6
Cement asbestos (chrysotile, crocidolite)	35	91	250–340	0.3	0.0	0.8	2.2

Table 4 shows the number of air samples taken in buildings with non-friable ACMs where agricultural, industrial, and machining activities were carried out. Mean concentration of airborne asbestos fibers, sampling time, LFL, UFL, and maximum concentration are also shown.

Table 4. Mean airborne asbestos fiber concentration measured in buildings other than public offices with non-friable ACMs. LFL, UFL and maximum concentration measured are also shown.

Activity	Number of Buildings	Air Samples	Sampling Time (min)	Mean Concentration (f/L)	LFL (f/L)	UFL (f/L)	Maximum Concentration (f/L)
Farms	6	18	250–340	0.5	0.2	1.2	0.6
Industrial buildings	4	10	250–340	0.6	0.2	1.4	0.8
Mechanical workshops	2	8	250–340	<0.4		0.4	0.4
Disused industrial sites	7	30	250–340	0.6	0.2	1.4	1.4
Storage warehouses	7	41	250–340	0.7	0.3	1.5	2.7

The highest indoor concentration values were measured in rooms with damaged exposed asbestos cement roofing (Figure 7).

3.3. Settled Dust Analisys

SEM-EDS analysis performed on settled dust samples taken from buildings with friable ACMs showed the presence of asbestos fibers.

Figure 7. Example of a damaged exposed asbestos cement roofing in indoor environments.

Interestingly, although the concentration of airborne fibers measured in these buildings (Table 1) was always below the set indoor limit value of 2 f/L, a non-negligible amount of asbestos fibers was found in the collected dust. Figure 8a shows some amosite fibers detected in a settled dust sample collected from a building with friable ACMs. Under these circumstances, the main concern was resuspension of the settled fibers in the air. Asbestos fibers were often found even in rooms where ACMs were absent and far from the areas where asbestos dispersion could be expected.

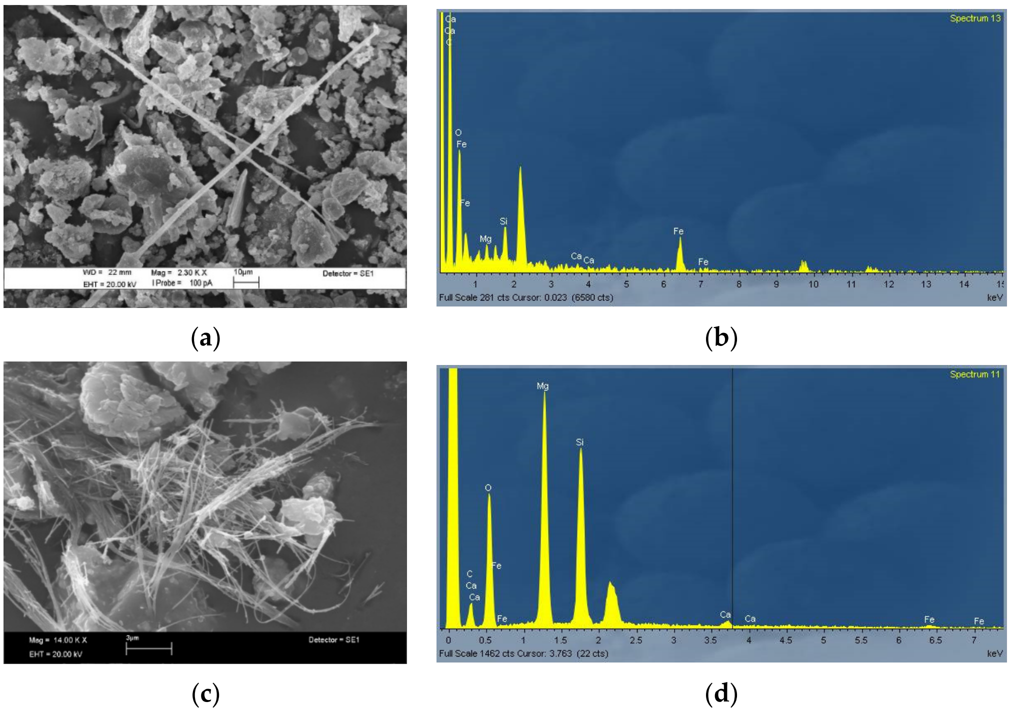


Figure 8. An example of SEM image of amosite (**a**) and chrysotile (**c**) fibers in settled dust samples collected in building A, with friable ACMs, and in a storage warehouse with non-friable ACMs, respectively. Related EDS spectra, ((**b**,**d**), respectively) are also shown.

Analysis of settled dust rarely showed asbestos fibers in samples taken in buildings where non-friable ACMs were present. Specifically, chrysotile fibers were detected inside warehouses with highly damaged and exposed asbestos–cement roofing (Figure 8b).

3.4. Statistical Analysis

Statistical analysis of the data showed no significant differences between the mean concentrations measured in buildings with friable and non-friable ACMs ($p = 0.258$). This result is in agreement with data in the literature [8,10].

4. Discussion

Although the use and production of asbestos and ACMs were banned in Italy in 1992 [2], the risk of asbestos exposure still exists because most ACMs have not been removed. They continue to be present in industrial environments and in buildings.

In this work 111 buildings were investigated. A total of five buildings had friable ACMs, while 80 were public buildings with non-friable ACMs and 26 were buildings with non-friable ACMs where agricultural, industrial, and machining activities were carried out. A total of 195 air samples were collected in buildings with friable ACMs; 305 air samples were collected in buildings with non-friable ACMs.

Mean concentration measured in friable ACMs buildings was 0.6 f/L. Those measured in public and other buildings with non-friable ACMs were 0.1 and 0.5 f/L, respectively. Statistical analysis of the data showed no significant differences between the mean concentrations measured in buildings with friable and non-friable ACMs. This result is in agreement with data in the literature [8,10].

All concentration values of airborne asbestos fibers were below 2 f/L, the value indicated by Italian regulation as the limit not to be exceeded in order to allow reoccupation of the buildings after asbestos removal [12]. Only in two cases the maximum concentration was above 2.0 f/L. These buildings had damaged asbestos–cement materials.

Although our airborne asbestos fiber concentrations measured were low, a precautionary approach requires an asbestos management program.

It is noteworthy that air sampling gives the number of airborne fibers at the time the sampling is done, without providing information regarding any antecedent fiber releases. The presence of asbestos fibers found in the collected dust shows the occurrence of a release of asbestos from the material.

Asbestos fibers were also found in settled dust collected in rooms far from areas where ACMs were present as a result of transport, resuspension in air and redepositing processes.

Among ACMs, it is well known that those considered most dangerous are friable materials, that can be easily crumbled by manual pressure [4]. The friability of an ACM is closely related to the ease with which it releases asbestos fibers into the environment. A previous study showed that in indoor environments where friable ACM was present, airborne fiber concentrations ranged from less than 1 f/L to even more than 10 f/L [20].

In buildings investigated in this work where friable ACMs were encapsulated or enclosed (A, D, E in Table 1), the release of asbestos fibers into the air was likely due to the presence of small cracks in the covering material. The maximum concentration values of airborne asbestos fibers measured were in the range 0.8–1.8 f/L. The concentrations measured in the absence of containment measures were in the range 1.0–1.3 f/L. By immediately intervening with restoration work, concentrations fell back to the detection limit value.

In non-friable matrices, such as asbestos–cement and vinyl asbestos, the fibers are embedded and, if the material is in good condition, are not released into the air.

Years after installation, asbestos–cement materials are subject to complex degradation that leads to a decrease in product consistency and the surfacing of asbestos fibers. This can occur in varying amounts depending on a number of parameters, such as exposure to atmospheric agents [21–24], pollutants [25–27] and fractures due to indirect (vibrations, etc.) or direct (maintenance interventions, demolition, or acts of vandalism) mechanical action.

The degradation suffered by the roofing may affect the condition of the ACM when it is exposed inside the building (Figure 7). This was the case for the clothing warehouse shown in Table 4, in which the maximum airborne asbestos concentration was 2.7 f/L.

Regarding vinyl–asbestos flooring, the release of fibers during normal use is unlikely, but they can be released if the floor is cut, abraded or perforated [12]. It was noted that a significant source of release of asbestos fibers into the air was likely due to abrasion between tile fragments and mastic and/or scraper [28]. In a recent study [29], abrasion, drilling and cutting were considered as source of asbestos dispersion into the air. Decay of the matrix incorporating asbestos fibers affected the release of asbestos fibers [30].

Our results from public offices showed that in the presence of vinyl–asbestos flooring, the dispersion of asbestos fibers was negligible (Table 3).

Low indoor exposures to asbestos in non-occupational settings are currently of great scientific interest to better understand the dose–response relationships.

Quantitative asbestos cancer risk assessment is required to quantify the exposure dose and the factors that determine its value, such as intensity, frequency and duration of exposure.

Asbestos is a proven human carcinogen. Exposure therefore should be kept as low as possible.

When an ACM is present in a building, current Italian regulation [12] recommends that owners and safety managers be well aware of the risks associated with this mineral and adopt an asbestos management program. The principal objective of this program is to minimize exposure of all building occupants to asbestos fibers. To accomplish this objective, some work practices are necessary to: maintain ACM in good condition, ensure proper cleanup of asbestos fibers previously released, prevent further release of asbestos fibers, and monitor the condition of ACM.

Union policy on the environment is to be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at the source.

In order to better protect people and the environment from asbestos and ensure an asbestos-free future, the European Commission intends to improve asbestos information through screening and registration of ACMs to introduce digital building registers for better sharing and use of building data from design to construction and demolition.

The Public Institution to which the authors of this work belong encourages asbestos removal as preferred abatement method, which is also in line with the European Commission's asbestos-free approach.

5. Conclusions

Statistical analysis of the airborne asbestos concentrations measured in ACM building showed no significant differences between the mean values calculated in buildings with friable and non-friable ACMs.

Most of the concentration values of airborne asbestos fibers were below 2 f/L, the value indicated by Italian regulation as the limit not to be exceeded in order to allow reoccupation of the buildings after asbestos removal.

Further, the presence of asbestos fibers found in the settled dust shows the occurrence of a likely release of asbestos from the material.

Although our airborne asbestos fiber concentrations measured were low, a precautionary approach requires an asbestos management program, as current Italian regulation requires.

The Public Institution to which the authors of this work belong encourages asbestos removal as preferred abatement method, which is in line with the European Commission's asbestos-free approach.

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