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MONITORING OF AIRBORNE FIBERS DURING ASBESTOS REMEDIATION: THE CASE STUDY OF THE "ETERNIT" SITE IN THE BAGNOLI-COROGLIO AREA OF RELEVANT NATIONAL INTEREST

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Abstract

As part of the broader implementation of the Environmental Remediation and Urban Regeneration Program (PRARU) of the Bagnoli-Coroglio area of relevant national interest (Naples, Italy), one of the priority actions was the completion of the soil remediation interventions of the former Eternit site, focused on the safe removal of soil and materials containing asbestos still present in the area (approximately 25,700 tonnes of hazardous waste).
This area has an extension of approximately 157,000 m² where the production of products containing asbestos had been carried out from 1939 to 1985. In 1997, the first reclamation activities began, consisting of the decommissioning of industrial structures and continuing with the removal of buried materials. These activities were interrupted in 2014 and then resumed in 2020 until completion at the beginning of 2023.
The activities, completed to date, were run under the constant control of the territorially competent "ASL Napoli 1", and with the implementation of a specific shared plan for monitoring airborne fibers both inside the construction site and outside in the surrounding areas.
In particular, environmental monitoring activities were performed before, during and post-operation on eight control units, three of which were located within the construction site and five in the surrounding areas at potentially sensitive targets, as well as personal sampling of the exposed operators.
The methods for identifying asbestos fibers were both phase contrast microscopy (MOCF) and scanning electron microscopy (SEM).
In both cases, the monitoring results never showed that the thresholds established by Italian legislation were exceeded, both in terms of total fibers and asbestiform fiber.

Introduction

As part of the broader implementation of the Environmental Remediation and Urban Regeneration Program (PRARU) of the Bagnoli-Coroglio area of relevant national interest (Naples, Italy), one of the priority actions was the completion of the soil remediation interventions of the former Eternit site, focused on the safe removal of materials containing asbestos still present in the area (approximately 25,500 tonnes of earth and rocks classified with code EER 17.05.03* and approximately 210 tonnes of construction materials containing asbestos (MCA) classified with code EER 17.06.05*).

Asbestos (or asbestos):

• it is a natural mineral with a microcrystalline structure;
• has a fibrous appearance (i.e. it is made up of bundles of very fine fiber, parallel to each other);
• belongs to the chemical class of silicates.

Asbestos fibers belong to two groups of minerals (Figure 1):
• Amphiboles (silicates of Ca and Mg) include crocidolite (blue asbestos), amosite (brown asbestos), anthophyllite, actinolite, tremolite;
• Serpentini (Mg silicates) includes chrysotile (white asbestos).
In products in which asbestos is present, the fibers can be:
• free or wweakly bound in a friable matrix;
• strongly bonded in a stable and solid matrix (such as asbestos-cement or vinyl-asbestos) asbestos in a compact matrix.
Asbestos in a friable matrix can be reduced to powder with simple manual action. Asbestos, on the other hand, is compact when it can be crumbled or reduced to powder only with the use of mechanical or electrical tools (abrasive discs, cutters, etc.)

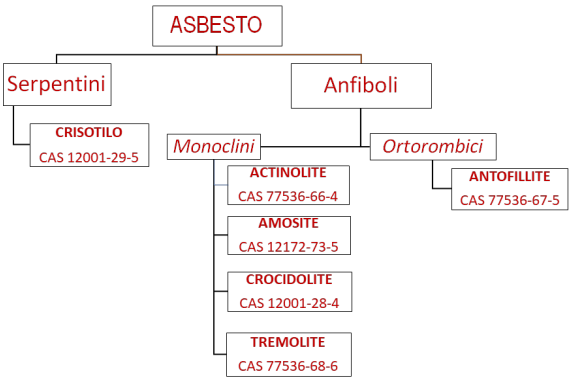

Figure 1 – mineralogical subdivision of asbestos fiber

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It is known that the toxicity of a fibrous material is based on the study of three factors, known in English as the three "Ds": dose, dimension and durability:
• Dose – refers to the number of inhaled fibers that are deposited in the alveolar regions of the lung, generally correlated with the development of pulmonary toxic effects
• Size – refers to the concept according to which thin and long fibers are more toxic than others, persisting longer in the lung
• Persistence (durability) – is determined both by the length of the fibers (longer fibers are able to persist more) and by the chemical composition (resistance to degradation in lung fluids or lung cells).
A fourth "D" is also taken into consideration: the distribution of fibers within the respiratory system. It is important to know the location of the inhaled fiber. The fibers recognized as the most dangerous, following deposition in the alveolar regions of the lung, migrate through the alveolar epithelial cells into the pulmonary interstitium.
Most airborne asbestos fibers are usually breathable and therefore more dangerous.
Asbestos is characterized by convoluted fibers up to 5 cm long and between 0.7 and 1.5 microns in diameter.
In a linear cm you can place:

- 250 human hairs.
- 1.300 nylon fibers;
- 335.000 asbestos fiber.

The penetration of asbestos fibers into the body can cause:

- a toxic action (asbestosis);
- a carcinogenic action (mesothelioma – lung cancer).

The former Eternit area covered by the case study has an area of approximately 157.000 m^2 and the production of products containing asbestos was carried out on it from 1939 to 1985 (Figure 2).

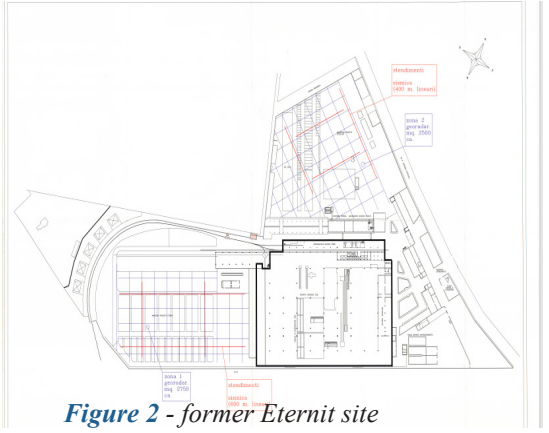

***Figure 2** - former Eternit site*

Following the introduction of legislation that banned the production and marketing of ACM (Asbestos Containing Materials) [1], the first remediation activities began in 1997, consisting of the decommissioning of industrial structures and continuing with the removal of buried materials. These activities were interrupted in 2014 and then resumed in 2020 until completion at the beginning of 2023. To ensure the protection of the health of workers and the population, environmental monitoring activities were carried out before, during and post-operam on eight control units of which three were located within the construction site and five in the surrounding areas at potentially sensitive targets, as well as personal sampling of exposed operators. In developing the design of the reclamation intervention, the opinions expressed during the meetings and technical tables of the scientific and control bodies were taken into account: INAIL (Istituto nazionale Assicurazione Infortuni sul Lavoro), ISS (Istituto Superiore di Sanità) and ASL NAPOLI 1.
Even during the period of inactivity (2014 - 2020) environmental safety measures were maintained.
In particular, the monitoring interventions were planned in terms of:
• monitoring in the vicinity of reclamation works (areas of excavation and removal of underground utilities);
• personal monitoring of the most exposed operator;
• environmental monitoring at the perimeter of the intervention areas;
• environmental monitoring outside the intervention perimeter and the Bagnoli-Coroglio area.

The instrumental technical methods for identifying asbestos fibers were both phase contrast microscopy (MOCF) and scanning electron microscopy (SEM).

Methodology and Materials

It should be noted that the main instrumental techniques for identifying asbestos fibers are:
MOCF – Phase Contrast Microscope:
• optical microscope in which phase differences (not visible) are transformed into differences in amplitude (light intensity);
• recognition of fibers based on morphological properties by subdivision into "asbestos-like" and "non-asbestos-like" (being asbestos-like is a necessary but not sufficient condition for a fiber to be asbestos);
• counting performed on the Walton-Beckett lattice;
• detection of fibers up to a minimum diameter of 0.25 µm.
SEM – Scanning electron microscope:
• electronic-optical microscope which allows you to analyze the signals produced by the interaction between an incident electron beam and the sample (in particular secondary electrons, backscattered electrons, X radiation)
• a portion of the filter, dried and clear, is metalized under vacuum (thin layer of graphite
• provides morphological, compositional and structural information relating to the various parts of which the sample is made; identifies individual fibers
• Allows you to detect fibers with a minimum diameter of 0.03-0.04 µm

In accordance with the technical regulations of the sector [2 - 4], in particular, of the Ministerial Decree 06 September 1994, the sampling methods used were:

• sampling with cellulose ester filter – filter with diameter 25 mm, porosity 0.8-1.2 µm, sampling flow 1-12 L/min (± 10%) and sampling volume 480 L;
• sampling with polycarbonate filter -filter with diameter 25/48 mm, porosity 0.8 µm, sampling flow 6-9 L/min (such as to allow capture speed of 0.35 m/s ± 10%) and volume sampling rate 3000 L (8L/min for 6 h).
The following Table 1 summarizes the sampling and analysis scheme carried out and validated by the control bodies.
The following image indicates the positioning of the sampling units within the construction site and

Kind of environment	Sampling type	Analytical Method	Reference thresholds	Normative requirements
Work environment (assessment of worker exposure)	Personal	MOCF	0,1 ff/cm3	D.Lgs 81/08 - Titolo IX – capo III
Confined living environment	Environmental	SEM MOCF	2,0 ff/l 20 ff/l	DM 6/09/94 punto 2c
External inspection of the reclamation site	Environmental	MOCF	50 ff/l*	DM 6/09/94 Punti 11/1-11/2
Returnability of reclaimed environments	Environmental	SEM	2,0 ff/l	DM 6/09/94 Punto 6/b
External environment	Environmental	SEM-TEM		-

** alarm threshold (pre-alarm threshold = tendency towards an increase in the concentration of airborne fiber)*

***Table 1** – sampling and analysis scheme*

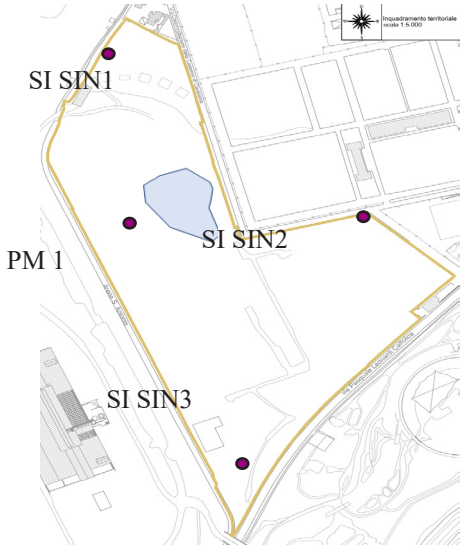

***Figure 3** – Positioning of sampling stations inside the construction site*

is represented in the following Figure 3
During the reclamation activities, monitoring took on two different configurations based on the work carried out, in particular:

1. **Excavation of land/fills and removal of underground utilities.** During these activities, monitoring was carried out by positioning 3 survey stations as shown in the following image (Figure 3a) and agreed with the control body of ASL Napoli 1.
To carry out the activities, 2 of the stations present on site were used, namely SI-SIN1 and SI-SIN 2 depending on the progress of the excavations, while the SI-SIN 3 station remained fixed and on the same it was carried out a weekly sampling. The third station necessary for monitoring the excavation activities (PM1) was provided by the person carrying out the activities, and carried out monitoring with sampling

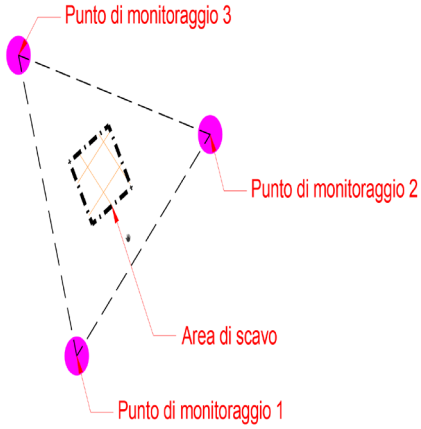

***Figure 3a** – Positioning of sampling stations inside the construction site*

mode with high flow pumps, 8-10 l/min, at least 3000 l sampled, filters /25 mm polycarbonate membranes with 0.8 µm porosity, with scanning electron microscopy (SEM-EDS) analysis equipped with a microanalysis system.
For the 2 Si-SIN stations 1 and 2, the sampling methods were as follows: environmental sampling with low flow pumps, 2-3 l/min, at least 480 lt sampled, filters/membranes in mixed cellulose esters or in 25 mm or 47 mm polycarbonate and 0.8 µm

porosity, with analysis in phase contrast optical microscopy (MOCF). The monitoring frequency was daily and the results were delivered to the Works Management within 24 hours.

For station No. 3 (SI-SIN 3) which remained fixed, sampling was carried out on a weekly basis with the following methods: sampling with high flow pumps, 8-10 l/min, at least 3000 l sampled, filters/ 25 mm polycarbonate membranes with 0.8 µm porosity, with analysis in phase contrast optical microscopy (MOCF). The monitoring frequency was daily and the results were delivered to the Works Management within 24 hours.

	Sampling type	Sampling mode	Analytical method	Duration
Monitoring Ante Operam	Environmental	High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity.	SEM	Daily sampling over 5 consecutive days. Monitoring phase aimed at verifying the natural background value.
Monitoring in progress	Environmental	High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity.	SEM	Biweekly sampling with an alarm threshold of 1 ff/l in analogy to what is indicated by the WHO for asbestos in city environments.
Monitoring Post Operam	Environmental	High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity and SEM analysis.	SEM	Sampling on a monthly basis for three months following the completion of the works and an alarm threshold of 1 ff/l.

Table 2 *– Sampling methods adopted for the construction site area*

For station No. 3 (SI-SIN 3) which remained fixed, sampling was carried out on a weekly basis with the following methods: sampling with high flow pumps, 8-10 l/min, at least 3000 l sampled, filters/ 25 mm polycarbonate membranes with 0.8 µm porosity, with scanning electron microscopy (SEM-EDS) analysis equipped with a microanalysis system.

2. **Remaining activities foreseen by the executive project.** During these activities, monitoring was carried out by positioning in the 3 points used in the pre-operam phase, with the following methods: environmental sampling with high flow pumps, 8-10 l/min, at least 3000 l sampled, filters/ 25 mm polycarbonate membranes with 0.8 µm porosity, with scanning electron microscopy analysis equipped with a microanalysis system (SEM-EDS). The monitoring frequency was weekly.

The sampling activities were carried out according to the following scheme (Table 2):

The monitoring external to the intervention areas and consequently external to ARIN, was carried out through the installation of five control units for monitoring airborne fiber, as requested by the ISS in the opinion attached to the Decree of 13 February 2019 of Extraordinary Commissioner with whom the definitive reclamation project was approved with prescriptions, and following discussions with the neighborhood committees which requested the installation of a control unit near a further sensitive point (e.g. schools).

The monitoring stations were the following:

1. Point 1 – Residential Via Cocchia - for the purposes of protecting the relevant devices, the station was positioned within the INVITALIA areas near the monitored entrance;
2. Point 2 – Residential Via Circonvallazione of the Cavalleria Barracks – the survey station was positioned at the ANM Cav depot. D'Aosta.
3. Point 3 – Cavalleggeri barracks - the station was positioned within the areas pertaining to the Cesare Battisti barracks of the Carabinieri.
4. Point 4 – Residential Via Leonardi Cattolica - the station was installed for the purpose of protecting the devices within the INVITALIA areas, near the entrance to the Sports Park.
5. Point 5 – Gigante Neghelli educational institute – the station was installed within the school district.

The positioning of the sampling stations outside the construction site is represented in the following Figure 4.

The sampling and analysis methods were as follows: environmental sampling with high flow pumps, 8-10 l/min, at least 3000 liters sampled, 25 mm polycarbonate filters/membranes and 0.8 µm porosity, with analysis in Scanning electron microscopy equipped with microanalysis system (SEM-EDS).

Ante-operam monitoring was carried out, in order to determine a possible whiteness value through sampling carried out over 5 useful days and the

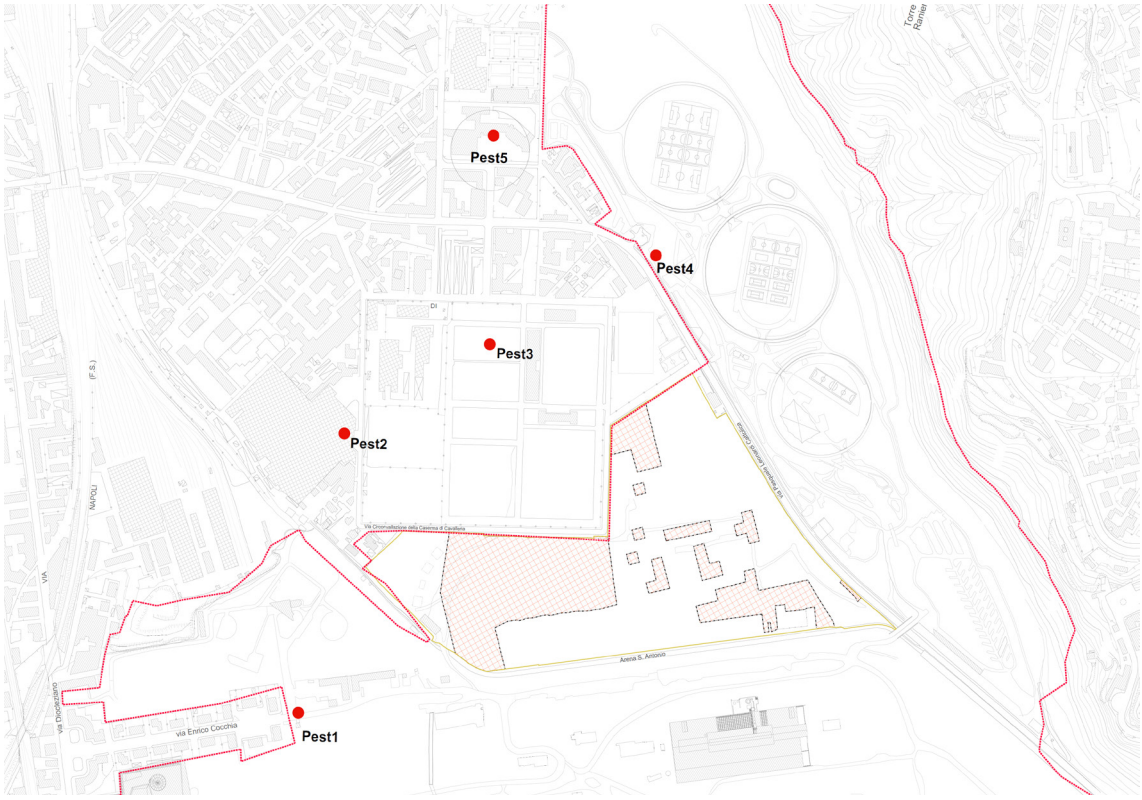

Figure 4 – Positioning of sampling stations outside the construction site

average value was obtained, monitoring during construction with initially weekly measurements, and following requests of the neighborhood committees bi-weekly surveys, and post-operam monitoring with a monthly survey for the three months following the completion of the works.
The sampling activities were carried out according to the following scheme (Table 3):

	Sampling type	Sampling mode	Analytical method	Duration
Monitoring Ante Operam	Environmental	High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity	SEM	Daily sampling over 5 consecutive days. Monitoring phase aimed at verifying the natural background value.
Monitoring in progress	Environmental Personal	stations YES SIN: High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity PM station 1 Low flow pumps 2-3 l/min and 480 l sampled with 25 or 47 mm polycarbonate or EMC filters and 0.8 µm porosity.	SEM MOCF	Daily sampling Pre alarm threshold at 20 ff/lt and alarm thresholds at 50 ff/lt. Monitoring around the excavation areas.
Monitoring Post Operam	Environmental	High flow pumps 8-10 l/min and 3000 l sampled with 25 mm polycarbonate filters and 0.8 µm porosity.	SEM	Sampling on a monthly basis for 3 months. Threshold value of 1 ff/lt. Monitoring in the three YES SIN points referred to in the white phase.

Table 3 – Sampling methods adopted for external areas

Results and discussion

Regarding the monitoring carried out outside the construction site area, with the SEM methodology, no airborne fibers in the environment have ever been detected in any survey station.
For each internal station (SIN1 and SIN2) n. 385 samplings and related analyses, over a period of over a year and a half of field activities.
As regards the monitoring carried out near the work areas, with MOCF methodology, the maximum value found is 3 ff/l, therefore well below the pre-alarm threshold of 20 ff/l.

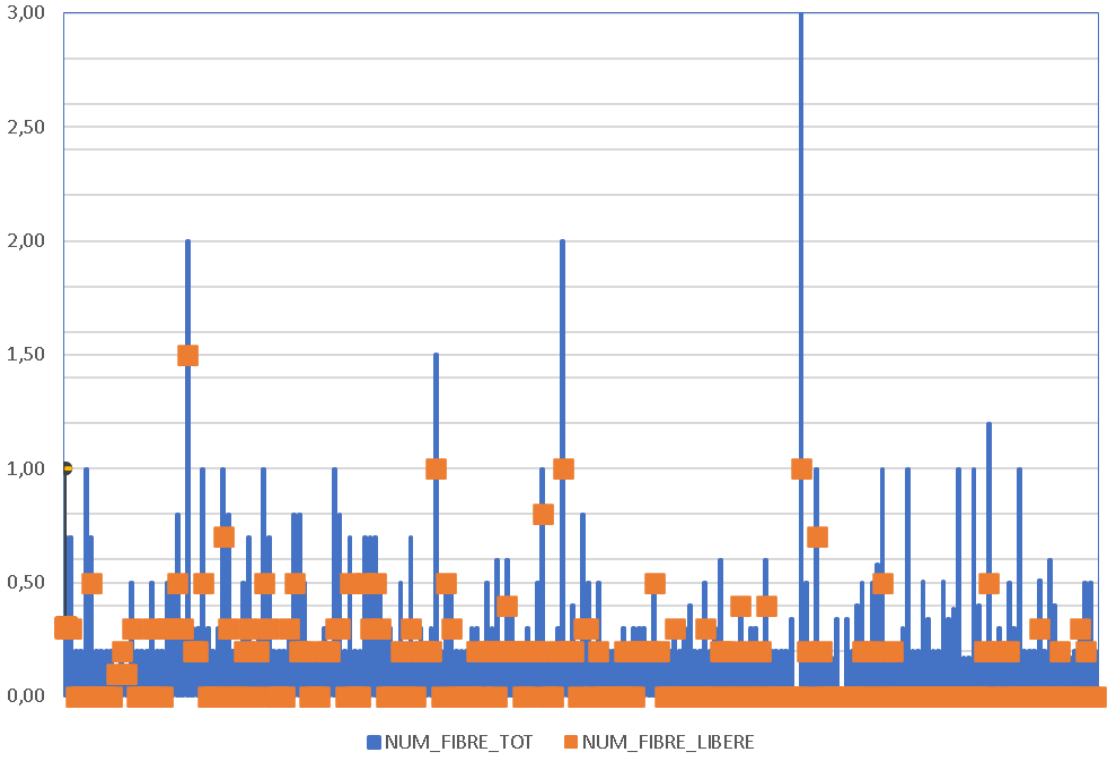

Figure 5 – *SIN1 monitoring station*

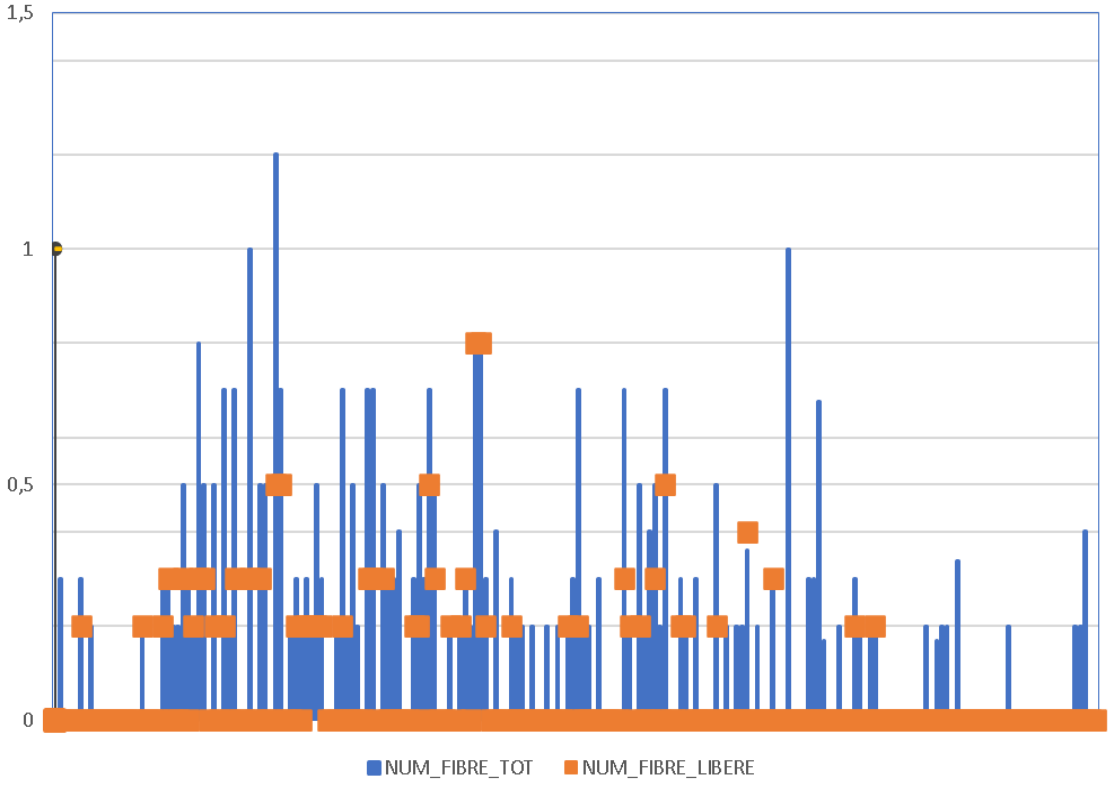

Figure 6 – *SIN1 monitoring station*

Conclusions

The monitoring activities as part of the completion of the reclamation of the former Eternit area - Area of Relevant National Interest of Bagnoli-Coroglio did not highlight any critical issues during the execution of the activities, neither at the construction site nor in the vast area.

This information objectively supports the correctness of the setting of the operating methods for carrying out the asbestos removal.

The interventions have to date been completed and certified by the same ASL Napoli 1 territorially

competent body.
The complete process of restitution of the places includes testing activities by the public control body "ARPAC" in relation to the reclamation objectives to be achieved relating to the specific intended use (ref. Environmental Consolidated Law Legislative Decree 152/2006: Tab. A and B), set according to the specific concentration of the contamination threshold in the soil and subsoil.

Bibliography

1. Law 27 March 1992, n. 257 - Rules relating to the cessation of the use of asbestos.
2. Ministerial Decree Ministry of Health 6 September 1994 - Regulations and technical methodologies for applying the art. 6, paragraph 3, and art. 12, paragraph 2, of law 27 March 1992, n. 257, relating to the cessation of the use of asbestos.
3. Legislative Decree 25 July 2006, n. 257 - Implementation of Directive 2003/18/EC of the European Parliament and of the Council, of 27 March 2003, relating to the protection of workers from the risks deriving from exposure to asbestos at work.
4. Legislative Decree 81/2008 Consolidated law on health and safety at work.
5. E. Robortella Stacul "Asbestos remediation interventions in industrial sites. critical issues and interactions between technical regulations and procurement codes". Oral presentation at the national conference "Non-specifically regulated and special asbestos remediation", Remtech Ferrara – 20th of September 2019.
6. E. Robortella Stacul "The interventions to complete the reclamation of the Ex Eternit site". Oral presentation at the seminar "Safety management in the environmental recovery and regeneration program of Bagnoli". Order of Engineers Province of Rome - 18th of November 2019.
7. D. Gresia "The monitoring system of airborne fibers in a large area". Oral presentation at the seminar "Safety management in the environmental recovery and regeneration program of Bagnoli". Order of Engineers Province of Rome - 18th of November 2019.