Proceedings of the 10th World Congress on New Technologies (NewTech'24)
Barcelona, Spain - August 25-27, 2024
Paper No. ICEPR 145
DOI: 10.11159/icepr24.145

Remediation Activities in Italian Superfund Sites: the case study of Naples - Bagnoli

S. Bellagamba[1], F. Paglietti[1], S. Malinconico[1], G. Bonifazi[2], S. Serranti[2], A. Aurigemma[2]
[1]Inail (Italian Workers' Compensation Authority - Research Division) - DIT - Department of new technologies for occupational safety of industrial plants, products and human settlements
via R. Ferruzzi 38/40, Rome, Italy
s.bellagamba@inail.it; f.paglietti@inail.it; s.malinconico@inail.it
[2]Sapienza – University of Rome - DICMA, Department of Chemical Engineering, Materials and Environment
via Eudossiana 18, Rome, Italy
giuseppe.bonifazi@uniroma1.it silvia.serranti@uniroma1.it; alice.aurigemma@uniroma1.it

Abstract **-** Until the 1990s, Italy was among the world's leading producers of raw asbestos fibres and Asbestos Containing Materials (ACM) and one of the most contaminated Countries in Europe. To reduce asbestos-related health effects, Italy has adopted many laws and regulations regarding exposure thresholds limits and remediation tools. The Italian Environmental Ministry (MASE) has identified 42 Italian Superfund sites, 11 of which are mainly contaminated by Asbestos. The highest levels of exposure occur during remediation activities in the 42 Superfund-Sites (SS) and during the management of asbestos containing waste in landfills, which requires specific procedures. INAIL-DIT, the Italian Governmental Occupational and Safety Institute, play a role as MASE scientific consultant on issues concerning workers protection, against risks caused by pollution, remediation and Asbestos Containing Waste (ACW) management.
The aim is to identify suitable Emergency Safety Measures, to suggest specific best practices for remediation concerning on site monitoring, laboratory analysis, safety measures. Moreover, aim of INAIL research is testing the advanced technologies available for friendlier working activities and analytical methodologies.
This paper describes the remediation of Bagnoli industrial facility (Naples), an Eternit factory which produced in '70s -80s asbestos cement products. The remediation has been analysed, considering a first phase focused on demolition of structures and facilities, and a second phase regarding the characterization, screening, removal and disposal of polluted soils. The project planned the complete removal of all industrial structures and asbestos dispersed in the soil/subsoil and the recovery of the clean fraction. This work highlights the remediation techniques used and the prevention and protection measures provided for workers and daily life areas.
This study, considering the high number of asbestos cement factories in the world, can serve as an important reference for similar situations at European or international scale.

Keywords**:** safety, asbestos, workers, contaminated sites, hazardous waste

1. Introduction

Italy is among the most active countries in preventing the risks of asbestos exposure; in fact, it is among the 69 countries in the world that have banned this carcinogenic substance (IBAS, 28/10/2022), [1] [2] and of these, few have specific legislation on the operational methods of remediation, mapping and management of asbestos-containing waste as Italy does.

To date, 42 Italian Superfund Sites (Ministerial Decree 468/2001) have been mapped in the national territory, including 11 sites where the main contamination is connected to asbestos. In these sites, alteration of the qualitative characteristics of the environmental matrices has been verified as not acceptable for human health and/or the environment, so their remediation is essential. This allows the remediation of the compromised areas and land reclamation, considering environmental, economic and sustainable aspects.

This article will illustrate the Inail-Dit procedures prescribed for this specific case study (Naples Bagnoli) highlighting the prevention and safety measures required for exposed workers.

2. Site description

The Bagnoli site is located in the western part of the city of Naples, identified by Italian Law 388/00 and initially perimetered by Ministerial Decrees 31/8/2001 and 8/8/2014, (Fig. 1) has a total extension of about 250 hectares and within it several productive areas including those of Eternit asbestos cement manufacturing plant.

The Eternit industrial area has an extension of about 16 hectares and bords the urban area of Fuorigrotta and Bagnoli and a dismissed steel plant (Fig. 2).

The production activity ceased permanently in 1985 following a deep economic crisis in the sector, which began as early as the 1970s, after the first studies on the danger of asbestos fibres. Various types of asbestos-containing materials (ACMs), mainly pipes and roofing sheets, were produced in the plants.

Based on the results of the characterization investigations, the "Plan for Completion of the Environmental Remediation and Recovery of the Bagnoli Industrial Area" was prepared and approved by the Ministries of Environment, Health and Productive Activities on July 31, 2003.

The Bagnoli remediation Plan provided for:

- The demolition of the structures and facilities still present in the Eternit area;
- The implementation of detailed characterization and land reclamation, aimed in the Company's intentions at obtaining a requalification and reuse of the area, changing the destination from industrial to "residential - public green area."

With these aims, the Environmental Ministry decided to involve the National Scientific Bodies, including Inail, in the evaluation of remediation preliminary project; moreover, it requested their participation in technical meetings, joint inspections with the Ministry officials and Local Bodies, as well as the submission of technical-scientific opinions on the final remediation project and subsequent ongoing revisions.

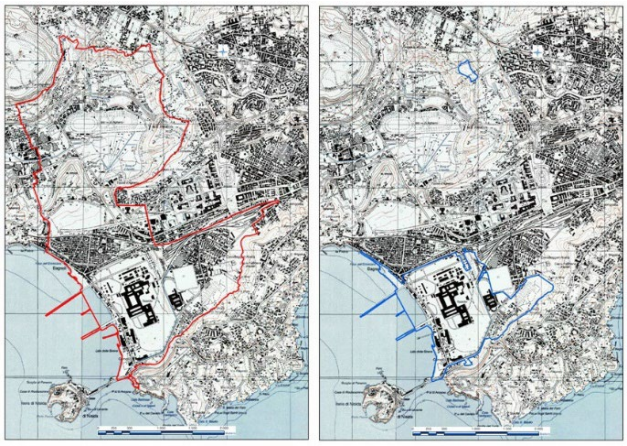

Fig 1 - Superfund area - on the left, the perimeter identified with Ministerial Decree 31/08/2001; on the right, the reperimeter identified with Ministerial Decree of 08/08/2014 [3]

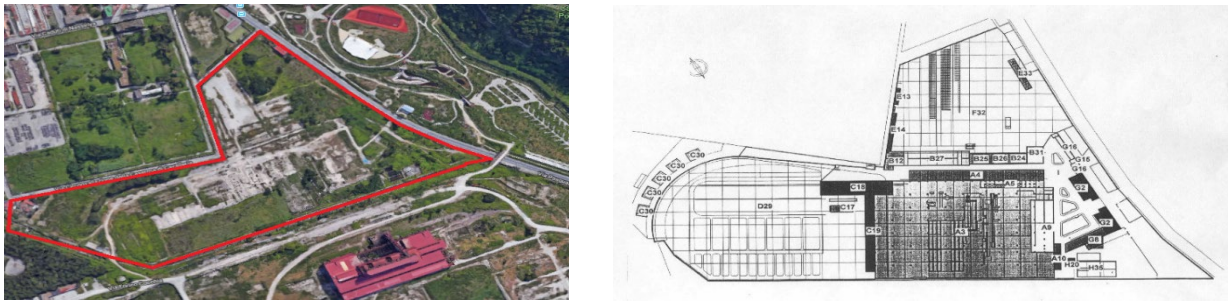

Fig. 2 – Eternit area and location of industrial buildings [3].

3. Remediation activities in the Eternit area

The remediation operations required the preliminary identification of the different types of Asbestos-Containing Materials (ACMs), their relative quantities, and their state of preservation. [4]

The cognitive phase led to the planning of specific remediation operations to be carried out by the following operational steps:

1) Characterization of structures and subsoil;
2) Removal of above-ground structures (buildings and industrial factories), sewerage networks and sub-utilities;
3) Remediation of some lots of land polluted with Asbestos Containing Waste (ASW) and processing scraps;
4) Remediation of the remaining lots of contaminated soils.

All these remediation steps have been evaluated, approved and carried out under Inail-Dit supervision.

3.1. Characterization of structures and sub structures

Over the entire area, samplings were collected using the technique of continuous drilling with circulation fluid, until they reached the water table or one meter below it. Cores were drilled following a regular statistical mesh consisting of elements of size 100 x 100 m. Next, a survey conducted by specialized consultants was carried out, aimed at verifying the presence of asbestos in the land surface layer (about 20 cm). Further characterization was carried out by coring with increasingly dense meshes of 50 x 50 m and 25 x 25 m, then completed with detailed coring with 16 x 16 m and 8 x 8 m meshes.

The analytical results obtained showed the widespread presence of ACW fragments in the soil but in disuniform manner up to, in some cases, 3 m depth. These findings can be traced to burial activities of processing scraps and waste produced during the factory production. The pollution, in fact, is represented by processing scraps of Eternit materials and pure crocidolite lenses. Specifically, from the examination of the cores taken, two main conditions of distribution of ACM fragments in the soil were found in different areas:

1. fragments of pipes and/or artifacts distributed in well-defined horizons;
2. fragments of pipeline and/or artifacts randomly dispersed within the soil.

3.2 Remediation site

3.2.1 Demolition of Bagnoli industrial buildings

The remediation of the plants began with a preliminary cleanup of the site of existing vegetation, and then proceeded with the removal of all ACMs from the plants, structures and their subsequent demolition, (Fig. 3) following the steps below:

1) Collection of compacted ACMs scattered within the industrial facilities;
2) Cleaning of asbestos-contaminated surfaces by vacuuming with absolute filters with a specially equipped mobile unit;
3) Cleaning walls and hoppers from residues material containing asbestos;
4) Removing asbestos cement roofing sheets and tiles;
5) Demolition of reclaimed building and industrial structures;
6) Washing and encapsulation of all materials to be sent for recovery;
7) Packaging, management and transportation to authorized facilities of the produced ACWs.

Fig. 3 Dismantling and demolition phase of the roofs [3]

The remediation activities were carried out with a static and dynamic confinement to prevent the dispersion of fibers into the surroundings area and with a constant personal and environmental monitoring of more exposed workers (considering their task) and areas.

The remediation described above produced large quantities of asbestos-containing material including about 150 tons of shrubs and brushwood, about 7,000 tons of compacted MCA and processing waste, about 600 tons of other types of non-asbestos-containing waste, about 400 tons of friable asbestos-containing waste, and about 450 tons of asbestos-contaminated soil. All these hazardous wastes were sent for disposal in authorized landfills. This material was disposed of in diversified landfills in consideration of AMCs types:

1. compact cementitious material was sent to two preliminary storage facilities located in the Lazio Region;
2. the friable material was disposed of in France at an inerting treatment center that uses a process of vitrification of RCAs (so-called "Inertam" process).

In conclusion, the remediation of the Eternit plant in Bagnoli was completed on December 13, 2000, with the production of a clearance certificate from the Local Health Authority (LHA) certifying that all the activities planned and approved by the Ministry had been carried out correctly and that the area could be reused.

3.2.2 Land remediation

Following the abatement of buildings and removal of related waste generated, the soil with the Eternit, was divided, for organizational, technical and logistical reasons, into 18 sublots ranging in size from about 6,000 to 18,000 m^2. These sub-lots were in turn divided into 40 sub-areas. Each sub- area was further subdivided into cells, in order to better manage safely the excavation work, the handling of materials, the viability of the vehicles used on site and for off-site waste transport.

In this phase, the soil remediation activity involved the excavation, selection and sorting of ACMs, including manual sorting by operators using Personal Protective Equipment's (PPEs), with the aim of proceeding to the complete removal of all ACWs dispersed in the soil and subsoil and the recovery of the fraction free of pollution; to this end, continuous analytical controls were ensured to characterize the selected wastes and established which materials were polluted or not, allowing the possibility of reuse only of the latter.

To realize the operational phases for sorting and screening of the ACW, a specific operational procedure has been developed by Inail-Dit characterized by significant difficulty in establishing the criteria for identifying and separating ACWs fragments from the soil and to operate in a safe way.

In particular, excavation activities were carried out by distinguishing the soils removed into two distinct types:

A) soil characterized by the presence of ACWs in compact matrix detectable on sight during excavation and absence of free fibres from characterization analyses.

B) Characterized by the absence of ACWs in compact matrix detectable on sight during excavation and absence of free fibres from characterization analyses.

Each type of material was collected in a defined and distinct area, to be subjected to dimensional separation activities through the use of the quartering methodologies to obtain the following particle size fractions:

- 0 to 10 mm;
- 10 to 30 mm;
- 30 to 150 mm;
- over 150 mm.

The presence of compact ACW fragments was found, in most cases, in grain sizes > 30mm. In short, the processing cycle can be summarized in the following steps:

1) cell excavation and sending in another area for sorting and classification of the material produced;

2) truck loading of the different fractions by crawler excavator;

3) unloading of the material in the area adjacent to the cell with posting of signage showing the type of material, origin and type of pollutant;

4) waste classification:

- Type A ACW present;
- Type B without ACW;
- Type A with ACW and PAHs;

- Type B without ACW but with PAHs;
- materials polluted with PAHs only.

5) picking up with a wheel loader (bucket of 2 m^3) of the material from the formed heap and discharge into the screen hopper;

6) manual sorting on the ground of the heap formed by the over screen material of grain size > 150 mm;

7) loading and sending to reuse cycles of the material from the ACW-free of asbestos;

8) manual sorting on the belt of the material of grain size 20/30 ÷ 150 mm;

9) visual inspection of the heap formed on the ground of grain size 10 ÷ 2 mm; handling toward reuse of the material of grain size 0 ÷ 10 mm, 10 ÷ 20/30 mm after certification of the absence of free fibres by the laboratory;

10) handling toward reuse of material of grain size 20/30 ÷ 150 mm;

11) encapsulation of ACW produced by sorting with bagging in big bags for disposal.

The sorting and screening operations were carried out in areas adjacent to the excavation cells to limit vehicle travel and handling of the material to be processed.

The excavated material was found to be about 90% composed of a mix of soil and ACWs (and/or production slurries) from previous demolition of underground structures, slabs, and industrial flooring; the remaining 10% was found to be a mix of soil and scrap iron, wood, etc.

The processing cycles adopted for the sorting of materials, were found to be suitable, after the tests conducted, both for the productivity required, given the significant quantities to be processed, and for the safety aspects of workers and living areas.

The main criteria were:

- minimization of handling by mechanical means to avoid fragmentation of materials and dispersion of dust into the environment;
- short screening cycle to reduce material falls from hoppers to belts and thus avoid fragmentation of materials and dispersion of dust into the environment;
- separation upstream of screening, of coarse parts to avoid fragmentation of materials and dispersion of dust into the environment;
- use of safety equipment and machinery to contain and abate the dust produced;
- use of nets with appropriate mesh size depending on the size of the compact ACWs present in the mix of heterogeneous material to be screened;
- visual inspection during production of the ground heaps of all particle size fractions prior to waste classification and storaging in big bags.

During the remediation activities, daily environmental and personal monitoring was carried out to verify the presence of asbestos fibres in aerodisperse.

Unexpected situations were encountered during soil remediation activities, also constituted an additional element of difficulty; specifically:

- ACM was sometimes found admixed with other materials, such as concrete residues, or mixed with soils of a pyroclastic nature, typical of the Phlegrean area. This has resulted in no-homogeneous waste with highly variable ACW content being sent for disposal.
- Frequently, ACW has been found also in areas that should not have been polluted.
- Findings of ACW have also occurred at depths of 3.00 m below ground level and have involved, underground structures (sewer networks, conduits, slabs, floor slabs, etc.) distributed over very large areas.
- Over the years, the estimated quantities of ACW detected in the field to be disposed of has increased significantly.

Removal methodologies have been tested in agreement with the competent LHA and approved after appropriate additions. Clearance certification of successful remediation of ACWs was issued by the LHA on job.

4. Inail contribution

In 2018, Invitalia S.p.A., presented the final remediation project. Inail - Dit [5] examined the complex documentation and prepared a technical and scientific advice with some relevant revisions with the purpose of improving safety among which the main-ones are:

1. In reclamation lots where the Characterization Plan has shown the presence of ACWs buried underground, it is considered appropriate to operate with static and dynamic confinements. The same should be prepared when critical situations not yet expected emerge during the excavation phases. The same should not exceed 10,000 m^3 in size, in order to allow the proper performance of the "Smoke Test" contacted preliminary the commencement of works. Appropriate PPUs and MDUs will also have to be set up at the entrance to each individual confined area.
2. For all the remaining reclamation lots, considered by the characterization as not polluted, it is considered appropriate to operate without such confinements.
3. All water used on site (from PDU, MDU, vehicle washing, etc.), in the event of its reuse should be subject to filtration using suitable systems capable of retaining particles equal to or greater than 3 microns in size. In addition, the water will have to undergo monthly controls during the first three months, the frequency of which may be re-evaluated following analytical findings. These controls should be carried out during all work phases on a biweekly basis providing also efficiency control, filters replacement. Analyses should be conducted by SEM, preferably at 4000x magnifications. The concentration value of asbestos in the wastewater shall not exceed 100 f/cm^3. Filters, if no longer efficient, shall be replaced and disposed of with EER code 15.02.02*.
4. All transport vehicles, materials and equipment necessary to perform the work shall be insert or get out from the confined area through the MDU.
5. Providing the use of half-mask with P3 filter or, if significantly increasing concentrations are detected or horizons with friable asbestos are found, the use of full-face mask, electro-respirator, etc. within the static/dynamic confined area. It should be noted that the use of electro-assisted devices ensures greater comfort.
6. It is requested that the installation of remediation site facilities take place on soil free of asbestos contamination. Otherwise, encapsulation of already paved areas or laying on a geotextile should be provided in advance.
7. Upon completion of the reclamation of the individual lots, verification of the absence of asbestos in the soil (TLV = 1000 mg/kg) by the local control authorities must be carried out by sampling and analysis at the bottom and on the walls of the excavation. In case of a positive result, the clearance certification must be issued. At the end of the work shift, safety footwear (high safety shoes or rubber boots) after thorough washing, should always be placed in the personal lockers to be provided in the dirty PDU locker room (not in the clean locker room) to avoid carrying contamination outside the risk area.
8. Suitable reduced work shifts should be provided in consideration of weather and climate conditions (generally each four hours); in extremely hot climate conditions, it is recommended to work during late afternoon and night.
9. It is considered appropriate to store a maximum of 500 m^3 for each lot with an aliquot being taken at each discharge of material, to form a single sample; instead of taking superficial and deep samples at the end of the entire accumulation.
10. The handling of the soils, even if classified as not contaminated must take place wet and in covered trucks.
11. ACWs, both compact and friable, must be embedded in a static and dynamically confined temporary storage area, marked with specific signs indicating the corresponding codes E.E.R. before they are sent to an off-site final disposal.
12. The vehicles leaving the Eternit factory must be decontaminated by using a suitable low-pressure washing system, in order not to disperse fibres in the air and contaminate external areas.
13. For precautionary purposes it is considered appropriate that operators driving vehicles wear disposable filtering face P3 (FFP3).
14. All analytical monitoring should be realized by remediation companies (ante operam, work in progress, post operam) and validated for at least 10% of the samples by the competent supervisory bodies.

5. Conclusion

In this article has been reported a historical excursus of the administrative and operational procedures applied during the remediation activities carried out in Bagnoli Superfund site.

The activities carried out concerning the remediation of structures and polluted soil were then described, highlighting the prevention and safety measures provided for workers and external Naples areas.

In fact, the Institute plays an important role of scientific technical advice on behalf of all the Public Administrations.

References

[1] WHO.(2019). Asbestos: https://www.who.int/ipcs/assessment/public_health/asbestos/en/.

[2] IARC. (2012). Asbestos (Chrysotile, Amosite, Crocidolite, Tremolite, Actinolite, and Anthophyllite), IARC, Lyon, http://monographs.iarc.fr/ENG/ Monographs/vol100C/index.php R. E. Kalman, "New results in linear filtering and prediction theory," J. Basic Eng., vol. 83, no. 4, pp. 95-108, 1961.

[3] Final project "Lavori di completamento delle attività di bonifica dell'ex area Eternit nel SIN di Bagnoli-Coroglio" arranged by Invitalia S.p.A. and approved by Government Commissioner.

[4] Bellagamba, S., Paglietti, F., Malinconico, S., Conestabile della Staffa, B., De Simone, P., & Lonigro, I. (2018). Remediation Activities in an Italian Superfund: Case Study of an Industrial Plant in Broni. 4th World Congress on New Technologies (NewTech'18), Madrid, August 19-21, 2018. Paper No. ICEPR 166. DOI: 10.11159/icepr18.166.

[5] F. Paglietti, S. Malinconico, B. Conestabile della Staffa, S. Bellagamba, P. De Simone, "Classification and management of asbestos-containing waste: European legislation and the Italian experience", Waste Management, vol. 50, pp. 130-150, 2016. ISSN: 0956- 053X.875.