INAIL

2022

ANALYSIS AND MANAGEMENT OF ASBESTOS-CONTAMINATED SOILS

INTRODUCTION

The term asbestos encompasses six fibrous minerals, including chrysotile, amosite and crocidolite, which are widely used commercially. However, their carcinogenic properties are well known, mainly linked to the inhalation of airborne fibers. Thus, the extraction, production and marketing of asbestos and Asbestos Containing Materials (ACMs) have been prohibited in Italy by Law 257/92. The Italian Government has issued further regulatory provisions aimed at limiting the risk of occupational or environmental exposures, mainly concerning the reclamation of ACMs, the safe management of Asbestos Containing Waste (ACW) and the definition of limit values for environmental matrices: air, water and soil. However, the activities of characterization, sampling and analysis of the latter are not yet sufficiently regulated and still pose significant problems, related to the structural and compositional complexity of this matrix.

ASBESTOS-CONTAMINATED SOILS

The soil can be contaminated by asbestos both due to polluting anthropogenic activities (former asbestos cement production plants, phenomena of surface abandonment or burial of ACW, etc.) and natural processes of weathering of asbestos containing rocks (so-called Green Stones) in areas where such lithotypes are found (*Natural Occurring Asbestos* - NOA). Natural phenomena such as erosion, transport, runoff or anthropogenic activities (e.g.: earthworks and excavation/extraction works) contribute to the alteration of the soil and its contamination. The presence of soils contaminated by asbestos is widespread in our country in a heterogeneous way, with hot spots in industrial areas and mountain areas (Alps and Apennines).

INAIL CONTRIBUTION CONCERNING ASBESTOS CONTAMINATED SOILS

Inail is involved in national and international technical contexts (UNI, ASTM, ISO, IWWG) for the development of standard procedures aimed at the characterization of asbestos contaminated soils; this in order to assess the risk level and to recommend safe remediation interventions. The Department of Technological Innovations and Safety of Plants, Products and Anthropic Settlements (Dit) has produced numerous technical documents in support of the Public Administration, concerning the characterization and remediation procedures for national Superfund Sites (SS). The most relevant cases are mentioned below:

- Broni and Bagnoli National Superfund Sites, in which layers of pure asbestos and crushed ACMs were found in the soils surrounding the former ACM production plants;
- Balangero and Biancavilla National Superfund NOA Sites, where rocks and soils containing asbestos or asbestiform fibers (Fluoro-edenite) were extracted for commercial purposes;
- Sarno River Regional Superfund Site, where widespread crushed ACMs were dispersed in the soil and sediments of the river bed by the flood of May 1998.

Inail produced new procedures and analytical methodologies for managing high-risk situations; further research is currently underway to define specific procedures for characterization and remediation of soils containing low asbestos concentrations.

ASBESTOS CONTAMINATED SOILS REMEDIATION

The Italian Legislative Decree 152/06 regulates the remediation procedure; it provides that the site characterization phase involves sampling and instrumental analyses, in order to identify the concentrations of pollutants, comparing them with the Contamination Threshold Concentrations (CTC)/Limit Values (LV).

Sampling can be performed based on different approaches (e.g. random or grid-based) depending on the site history and presumed contamination (e.g. localized or spread out). At the national and international level, incremental sampling has seen a notable development, in which the sample is made up by taking several amounts from different points. The Italian reference technical standard (Legislative Decree 152/2006 - Ann. 2 Title V) furthermore provides the on-site separation of the fraction greater than 2 cm, by sieving. However, this operation involves risks of underestimation of coarse ACW fraction. As regards airborne fibers dispersion during sieving phase, it is advisable to carry out wet operations and wearing suitable Personal Protective Equipment (PPE) for worker's protection.

The subsequent analyses have to be carried out in laboratories participating in a round-robin circuit coordinated by the Ministry of Health, based on Annex 5 of Min. Decree 14/05/1996. Workers operating in laboratory should operate by adopting collective and individual protection devices, including laminar flow hoods equipped with absolute filters and P3 mask.

Italian threshold limits are 0.1% weight/weight in residential/industrial sites (Annex 5 to Title V of Legislative Decree 152/06) and 0.01% weight/weight (w/w) in agricultural sites (MATTM Decree no.46 of 01/03/2019). Where the analytical results show a percentage by weight of asbestos greater than these-ones, these soils are to be considered contaminated and therefore to be subjected to the risk assessment in order to evaluate the appropriate remediation procedures. However, difficulties persist in identifying analytical techniques able to guarantee the respect of aforementioned limits with sufficient levels of sensitivity, accuracy and reproducibility.

Considering the complexity of the characterization and risk analysis phases and the related economic burdens, in high-risk situations (e.g.: soils surrounding former asbestos-cement industrial plants) a precautionary practice has been adopted in Italy sending directly the contaminated soils to landfill. In other countries (USA, UK) the so-called *Activity Based Sampling* has been adopted for risk assessment. This process samples the airborne fibers during a reproduction of the activities that are planned or intended to be carried out in the investigated site.

Image: Contaminated soil around deteriorated asbestos-cement pipe.

ANALYTICAL METHODS

The Italian legislation (Annex 5 to Title V of Legislative Decree 152/06) provides for the use of Fourier Transform Infrared Spectroscopy (FTIR) and/or X-Ray Diffraction (DRX) for the analysis of asbestos in soils. Annex 2 also establishes that these techniques must guarantee an analytical sensitivity 10 times greater than the legal limit. The commercial instruments currently available rarely guarantee a detection limit higher than 1% w/w, with poor reliability of the analytical results in the case of low concentrations. However, these techniques are advantageous to identify asbestos in concentrations above these limits in a timely manner; they can now be used on-site by means of portable instrumentation, which enables a reduced sample preparation (grinding and homogenization) and a quick analysis. This makes it possible to carry out an on-site screening of the risk level and the quick identification of highly contaminated soils.

To deal with the critical issues related to low concentrations, on a national and international scale, further analytical techniques are adopted, such as Polarized Light Optical Microscopy (PLM) and/or Phase Contrast Microscopy (PCM) and Scanning (SEM) or Transmission (TEM) Electron Microscopy equipped with an Energy Dispersion System (EDS). Specifically, the microscopy mentioned techniques make it possible to visualize the single fibers, to classify them with precision and to count them; although they have a high analytical sensitivity, they involve executive complexity, poor reproducibility of the analysis and significant costs. For electron microscopy, with which infinitesimal fractions of the sample are analyzed, there is also the problem of the representativeness of the analysis.

The main solution to the problem is the adoption of alternative sample preparation procedures, often realized by enrichment of the fibrous fraction. In this case, however, the main limitation is the failure of legislative transposition, with consequent application hurdles in terms of legal effects.

Above the most applied international procedures are reported:

1. the HSG248 method (HSE, 2005) is mainly applied in the United Kingdom; it is based on PLM, with the possibility of supporting electron microscopy and/or carrying out the enrichment procedures developed by the *Institute of Occupational Medicine*. The method includes an enrichment procedure, similar to those indicated by the ISO 22262 standard for ACMs, which allows the increase of the detection limit of the analysis by dispersing the sample in water and applying a fractional sedimentation. It should be noted, however, that these enrichment methods encounter application difficulties in case of clay minerals presence in the soil, which have long sedimentation times;
2. elutriation is mainly applied in USA; this is an alternative enrichment technique using an air flow to separate the fibers from the matrix, sending them to a battery of air sampling cassettes;
3. ASTM D7521-16 standard published in the USA, is based on PLM and optionally on TEM (for the fine fraction), following sieving only. The choice of avoiding the grinding of the sample allows the preservation the crystal structures and increase the reliability of the method.

A procedure similar to the D7521 standard has been developed by an Italian Regional Environmental Protection Agency (ARPA Emilia-Romagna). It provides for Stereo and PLM analysis on the sample sieved at 2 cm and subsequent XRD analysis on the manually separable fraction extracted from the soil sieved at 2 mm.

Advanced technologies, such as Raman spectroscopy, X-ray micro-fluorescence (XRF) and *HyperSpectral Imaging* (HSI), are being evaluated by Inail Dit for screening analysis, even on situ.

CONCLUSIONS

The characterization of asbestos contaminated soils is a complex task, mainly due to the variability of the host matrix and the physical-chemical characteristics of asbestos minerals. The current national and international legislation show significant gaps; thus, there is a frequent use of "hybrid" methodologies, which use several analytical methods together.

In order to contribute to overcoming this problem, Inail-Dit is carrying out advanced research projects, in collaboration with universities, research centers and other international standardization working groups. Many tests are being conducted by using fast and innovative techniques (HSI, micro-XRD, micro-XRF, etc.) on soils, terrains and excavation materials, from building and infra-structural works (excavations/tunnels). The aim is to evaluate the reliability and accuracy of such techniques and to identify and disseminate new methodologies, which could contribute to reducing time, costs and risks during sampling and laboratory analysis.

REFERENCE LEGISLATION

- Law 257/1992 Rules relating to the asbestos ban
- Min. Decree 06/09/1994 Regulations and technical methodologies for the application of art. 6, paragraph 3, and of art. 12, para-graph 2, of Law no. 257 of 27 March 1992, relating to the asbestos ban;
- Legislative Decree 152/06, Environmental consolidated law;
- Min. Decree no. 46 of 01/03/2019 - Regulation relating to reclamation, environmental restoration and safety, emergency, operating and permanent interventions, of the areas intended for agricultural production and breeding, pursuant to article 241 of Legislative Decree no. 152 of 3 April 2006.

ISBN 978-88-7484-736-5 © 2022 Inail. The publication is distributed free of charge and therefore its sale and reproduction by any means is prohibited. Only the reference to the source is allowed.
Printed by Inail Tipolitografia in Milan • Edition 2022 **Authors: F. Paglietti, S. Malinconico (Inail Dit) - S. Serranti, G. Bonifazi, I. Lonigro (La Sapienza University) • Graphics and Editing: Coglianì DG**

Inail - Dipartimento innovazioni tecnologiche e sicurezza degli impianti, prodotti e insediamenti antropici - Direttore: Carlo De Petris
Via Roberto Ferruzzi, 38/40 - 00143 Roma
Tel. 06 548 76 400 • Fax 06 548 76 413 • dit@inail.it