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Management Of Asbestos-Cement In Excavated Earths

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Abstract **–** The design and adoption of suitable treatments for contaminated/uncontaminated fractions contained in excavated soils is usually carried out in order to reduce resource consumption and waste disposal. In this work, an *ad-hoc* designed process for separating asbestos-cement fragments from excavated soils and earths is proposed. It is based on a sequence of mechanical treatments and different analytical approaches to evaluate decontamination. The paper is focused on sampling and analytical issues, together with critical safety measures that are needed in order to reduce the release of airborne fibers.

Keywords**:** asbestos-containing materials, asbestos-containing soils, excavated earths, recovery, safety measures

1. Introduction

The term asbestos includes six fibrous minerals that have been classified, by the World Health Organization, as carcinogenic. Among them, chrysotile, crocidolite (i.e., fibrous riebeckite) and secondly amosite have been mined and commercialized, mainly in the last century, as Asbestos Containing Materials/Products (ACMs/ACPs), that in most cases are based on cement matrices (e.g., slabs/sheets, pipes, etc.). The residuals of asbestos-cement are usually classified as a particular type of Asbestos-Containing Waste (ACW) and are managed mainly by disposal in landfills. In few countries they can be treated, mainly in thermal plants, in order to make secondary safe materials.

Residues of ACMs may be generated and released into the environment during their production, or during remediation/abatement/disposal of ACW. Therefore, soils can take asbestos from both natural (i.e., rocks) and anthropic sources - the former are commonly referred as Natural Occurring Asbestos (NOA). In anthropized sites, frequently asbestos-cement fragments are found during earth excavations, moving, filling, etc., together with different products and residues. Usually, the contractor who detects asbestos implements early safety measures, then carries out a preliminary investigation aimed at evaluating contamination levels and spatial distribution.

The health risks posed by Asbestos-Containing Soils (ACSs) are mainly related to inhalation of fibers released into air [1]. Since aerodynamic models are unsuitable to predict fiber diffusion/transport processes, the safe management is based mainly on proper precautionary measures.

Regulations provide for limit/thresholds values to characterize, classify and manage soils and excavated earths as hazardous waste. Such limits are similar to those applied to ACW. The most adopted limit values lay within the range 0.001 – 0.1% by weight, depending on land uses and source conditions [2; 3].

However, ACMs can be found either in friable or solid/bounded state. Since the former has an high releasing potential, strictly safety measures are usually applied and all the excavated materials are disposed of. The latter case is typical of asbestos-cement waste, that usually generates lower risks, but attention must be paid to its degradation/breakage level.

When the contaminated fraction is composed mainly by asbestos-cement, two management approaches may be adopted: one which tends to remove and dispose of the whole mass and another which aims at treating the materials and reusing the uncontaminated fractions. Asbestos destruction processes may be the third way but, actually, they are too expensive and complex. Some regulations adopted the second approach and permit to remove ACMs fragments from soils/excavated earths through mechanical separation (i.e., screening) and operating a different management of the obtained fractions. Basically, once within a fraction the asbestos is detected in concentration lower than the related limit value, the fraction may be re-used, as suggested by circular economy principles. In this case, different analytical methods are needed.

Environmental standards are available to characterize soils and excavated earths. This process can be a difficult task, because both hosting matrices and contaminant distribution may be highly heterogeneous. Moreover, free asbestos fibers may be very thin (< 0,1 µm – also called *fines*). Therefore, the quantification of asbestos is more and more difficult as it approaches the limit values and, in turn, a case-by-case assessment is required.

When fragments of asbestos-cement are found during excavations, different granulometric fractions may be screened, analysed and managed using a stepwise approach [4]. Since the mechanical treatment may release fibers, correct Health, Safety and Environmental (HSE) protection measures must be adopted. Even if a proper HSE system is necessarily site-specific, some generic indications have been drafted and reported here.

2. Treatment process

The main activities of the process are based on: 1) a sequence of dimensional and qualitative screening (i.e. sieving) aimed at detecting ACW in two (or more) coarse fractions; 2) the quantitative analysis of asbestos in the fine fraction, containing both the excavated soil and its skeleton. The number of iterations and the used size class fractions should be chosen on the base of a preliminary characterization. However, standard granulometric parameters for soil (< 2 mm) and its skeleton (2 cm – 2 mm) should guide the choice of proper size classes and provide for readily analyzable fractions. Also the treated mass should be chosen on a site-specific approach – the authors suggest 500 - 1000 m^3 lots. If there is a high uncertainty regarding either the treatment or the analysis procedures, then a pilot test may be carried out, in order to measure the levels of airborne fibers that are released by the treatment. The test should be conducted in a confined area with mobile screening machines, preferably vibrating and functioning at low belt speeds.

2.1 Coarse fractions

The first screen is aimed at separate coarse pieces of ACMs and other anthropic/natural materials. A suitable screen-size for excavated earths may be 15 cm. Machines such as bucket/trommel/bar grates may be used at this stage. The retained fraction should be qualitatively screened by the operators, with the aid of fast analytical instruments like Near InfraRed (NIR)/Raman spectroscopes, or Hyperspectral Imaging (HSI) systems. At this stage, in depth-analyses may also be conducted with traditional techniques to avoid false-negative results. Any detected ACM must be prepared for disposal via standard procedures (i.e., confinement, encapsulation and bagging), while the asbestos-free materials can be separately treated, reused, recycled or disposed of, depending on their nature.

The fine fraction is screened again with a lower screen-size (it may be directly conveyed to a second screening machine), with the same procedures. Reasonably, the lowest screen size should be no less than 2 cm, because manual sorting of finer fractions is unfeasible. Finally the fine fraction must be sampled and quantitatively analysed for asbestos detection.

2.2 Fine fraction

Sampling

Different sampling strategies have been published for soils and excavated earths, thus the most suitable should be chosen on a site-specific approach, taking into account spatial and textural heterogeneity [5]. Sampling of stockpiles is usually carried out via manual techniques (e.g., coning and quartering). The authors suggest the adoption of incremental sampling strategies and automatic devices, which may be mounted on conveyor belts, that should lead to less biased results. Moreover, when sampling a 500 - 1000 m^3 lot, the minimum sample weight may be averaged in 50 kg, according to Gy's Equation and technical standards [5].

Sample preparation

Different approaches may be used in laboratory for comminution/subsampling, mainly depending on the analytical technique, the sample granulometry and the available milling machines. The comminution of the whole 50-Kg (dry) sample is suggested to homogenize it and obtain reliable results. The most used mills can reduce samples with granulometry < 2 cm to either 1 cm or 1 mm grain size. A final granulometric dimension ≤ 2 mm is recommended. Then, 1-Kg subsample will be collected and milled again, depending on the analytical technique.

Alternatively, *ad-hoc* preparation procedures may be carefully evaluated, for instance based on sieving and further analysis of separated fractions, or gravimetric matrix reduction (6; 7).

Analysis

Low-sensitivity analysis of ACSs may be performed via X-Ray diffractometry and IR spectroscopy. These techniques are mostly used to analyse anthropic materials, because they are not capable to recognize mineral habits/shapes and the Limit of Detection (LOD) is around 1% by weight. Nevertheless they are required by some national regulations for analysis of ACSs [2].

High-sensitivity techniques are based on optical/electron microscopy. The authors propose the adoption of a sequence of increasing sensitivity, using stereomicroscopy, Polarized Light Microscopy (PLM) and Scanning Electron Microscopy (SEM), which is feasible in most cases. Only when very low fibers concentrations and high risk levels are registered, we recommend in-depth analyses via PLM-visual estimation/point counting (LOD around 0,25% by weight) and Transmission Electron Microscopy (TEM) to increase sensitivity/LOD, according to ASTM D7521 method [6]. This is the only one international standard available for ACSs analysis.

The TEM sensitivity can go much further than the most common limit values for ACSs, hence if the results are negative, the safeness is guaranteed and the fine fraction may be recovered.

On the other hand, microscopy techniques require skilled analysts. Moreover, electron microscopy needs complex sample preparation and could result unreliable, because the analysed quantity could be unrepresentative.

Research is ongoing on the development and assessment of fast spectroscopy-based analysis, conducted with high-sensitivity portable instruments.

3. Safety measures

Since bounded ACMs does not tend to release fibers into air, they are usually managed adopting less safety measures than those used for friable asbestos materials. However, when asbestos-cement fragments are moved and sieved within a matrix, fibers could be released into both the coarse, the fine fraction and the air, hence the health risks may rise up. Therefore, it is necessary to adopt a proper HSE management system. Standardized procedures that are not soils-specific are available to protect both environment, workers and people living/working in the surroundings [8]. Some ACSs-specific measures are proposed by the authors and reported in the following (other basic measures such as access/vehicles speed limitations are omitted).

The coarse ACMs fragments that have been detected during screening and qualitative analysis must be managed and prepared for disposal in a confined environment, while the fine fraction < 2 cm may be stored in confined areas before sampling and analysis.

Low-pressure washing platform should be installed to decontaminate vehicles. A water purification unit (e.g., with final filters ≤ 3 μm) is recommended to reuse the exhaust waters coming from the washing platform and from the Personal Decontamination Units (PDU) and prevent environmental contamination.

Hepa vacuum systems have to be used for cleaning vehicles and PDU interiors.

Encapsulants/dust abatement systems are necessary to reduce airborne fibers levels and should be always and constantly adopted. This would also help preventing cross-contamination of samples.

All collective devices (e.g., PDU) and personal protective equipment (respirators/masks, gloves, disposable overalls, rubber boots, etc.) must be accurately chosen and used. At least P3-half masks should be worn in confined areas. Workers should be carefully trained for the specific risks.

Finally, a plan must be designed to monitor environmental pollution and workers' exposure.

5. Conclusion

The management of asbestos-containing soils and excavated earths pose complex issues and requires the application of different legislation and technical standards, that often should be better defined.

The proposed treatment is feasible when asbestos-cement fragments are detected during earths-involving activities (excavations, movements, fillings, etc.), that are conducted in sites both uncharacterized and under remediation. Of course, great attention must be paid to prevent environmental contamination and occupational exposures to airborne fibers, therefore proper precautionary and protection measures should be always selected on a case-by-case approach. The management only by landfilling leads to dispose of massive amounts of excavated earths as ACW and it may be in contrast with circular economy principles, for soil consumption, costs and remediation time.

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