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Identifying, controlling and preventing cross contamination in the OSI field laboratory - Risk Assessment Cross Contamination Tool (RACC)

Alberto Ubaldini, Antonietta Rizzo, Chiara Telloli, Fabio Borgognoni, Giuseppe Ottaviano, Naomi Falsini

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Italian National Data Centre - Radionuclide Component

INTRODUCTION AND MAIN RESULTS

The ENEA, NUC - TNMT Laboratory has been working since many years on difficult-to-measure radionuclides and low level activity isotopes. To achieve low level measurement, dedicated equipment is required as well as specific protocols for the analytical plan. During an on-site inspection (OSI), a field laboratory will be run to measure relevant OSI radionuclides, in samples collected in the inspected area. The field laboratory will not have the same performances of an off-site laboratory but nevertheless should achieve some requirements. One crucial aspect to pay attention to is to avoid cross contamination of the samples. Several protection actions can be applied to avoid cross contamination: segregation, cleaning, material handling, staff training, ect. Not all these actions are fully applicable during an OSI due to time and resources constrains.

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Introduction

Cross contamination is the unintentional transfer of foreign substances, such as microbes, chemicals, or other materials, from one object or sample to another within a laboratory setting. This contamination can lead to compromised results, affect the integrity of experiments or tests.

Cross contamination is something that requires the utmost attention and affects numerous sectors where proper sampling is crucial.
It can lead to false positives or negatives in environmental samples, making it difficult to definitively identify the source of a nuclear event, which is the goal of an of on-site inspections (OSI)

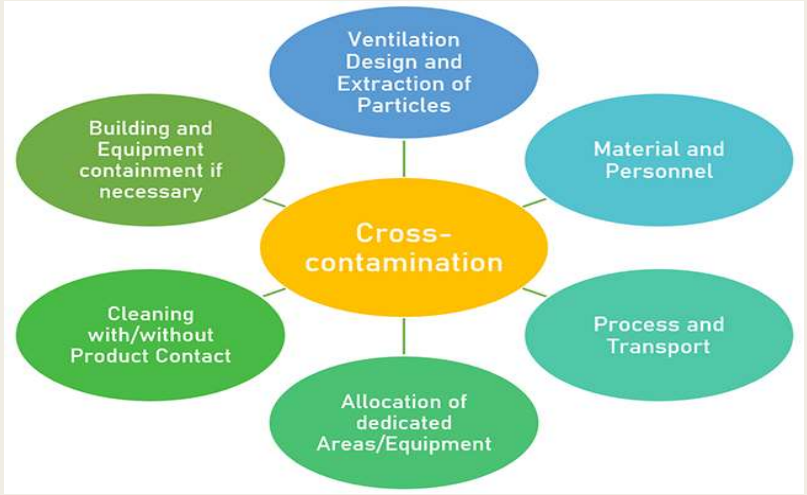
In the case of CTBTO refers to the inadvertent transfer of radioactive or environmental samples and other substances between equipment, samples, and areas, which could compromise data integrity, particularly in the case of OSI.

Possible sources of cross contamination

Cross contamination is caused by the inadvertent transfer of foreign material to evidence, which can happen through human error. Other causes include contaminated tools and equipment, environmental factors like airborne particles, and improper storage where samples mix.

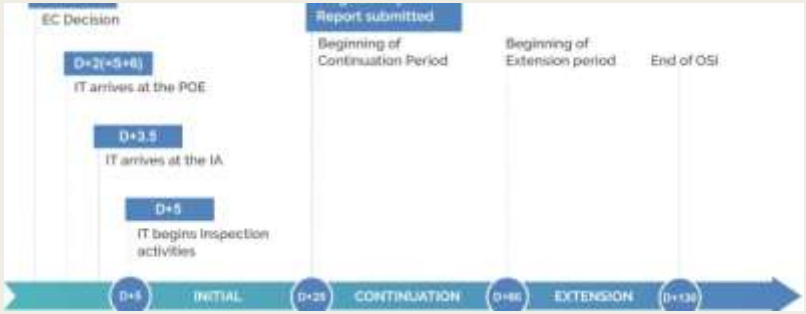
Insufficient training for technicians can lead to mistakes in evidence handling and preservation.

Failure to clean or replace gloves, tools, and other equipment regularly leads to transfer. Storing different samples in close proximity can result in unintended mixing



Consequences of cross contamination

Cross contamination poses a serious risk to the scientific integrity of OSI, a crucial part of the CTBT's verification process.
The unintended introduction of extraneous from OSI, can compromise its integrity. This phenomenon can occur at various stages, including during the initial collection, transportation, storage, or analysis of evidence. The preservation of evidence purity is crucial, as contaminated samples may lead to incorrect conclusions
In OSI, the risk of cross-contamination is high due to the large area that must be investigated, the number of samples that must be collected, and the time available to complete the inspection.



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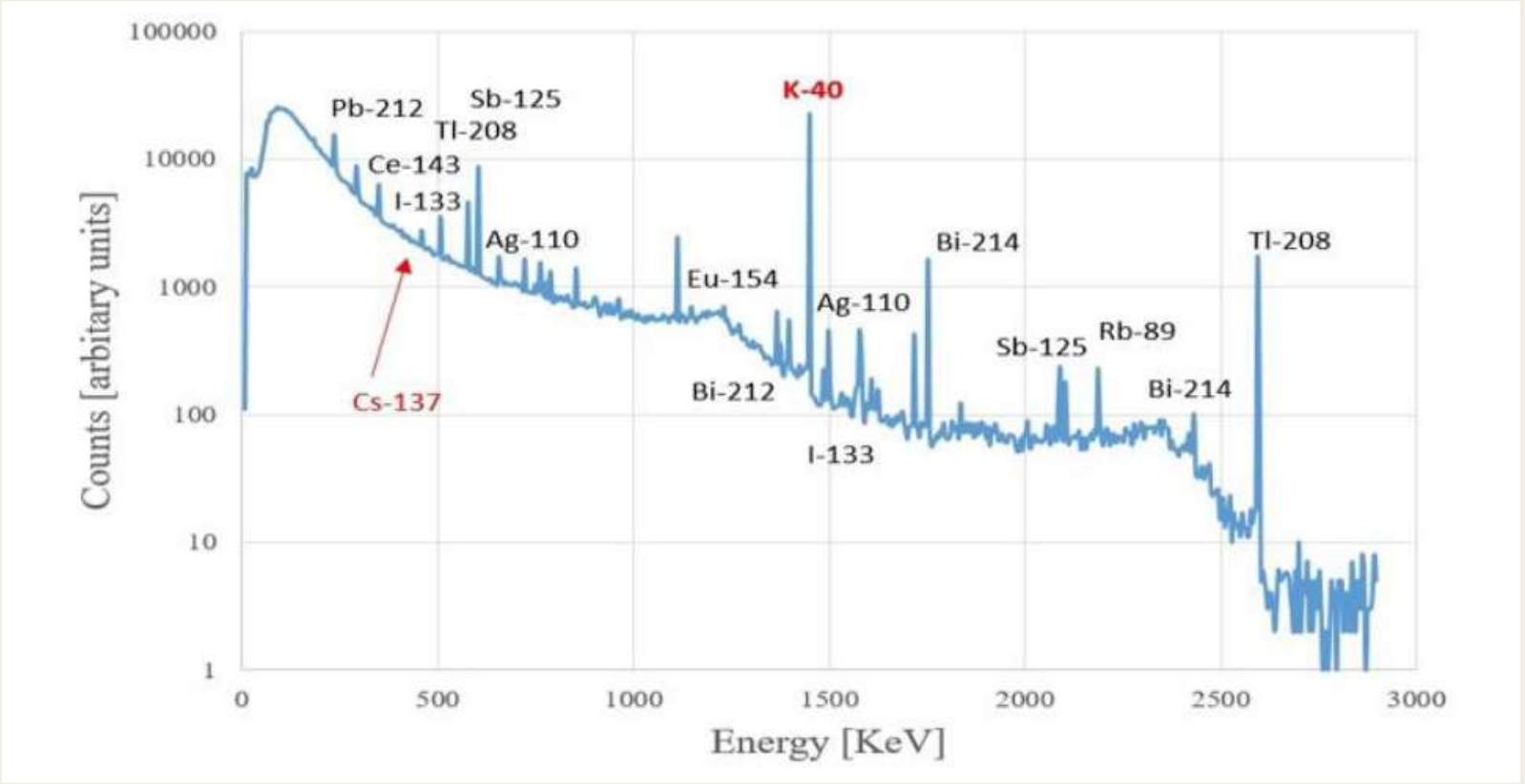
Soil analysis by gamma spectroscopy with portable instrumentation.

The first phase of an inspection during an OSI involves collecting interesting, unusual, or suspicious samples and characterizing them locally with various instruments, usually portable. Initially, this must be done relatively quickly. In a second phase, the most significant samples can be analyzed in greater depth in the laboratory, using different instruments and taking longer.

AMETEK ORTEK Ultrapure Germanium Portable Detector



Typical gamma spectrum of a generic soil.

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Evidence of a cross contamination

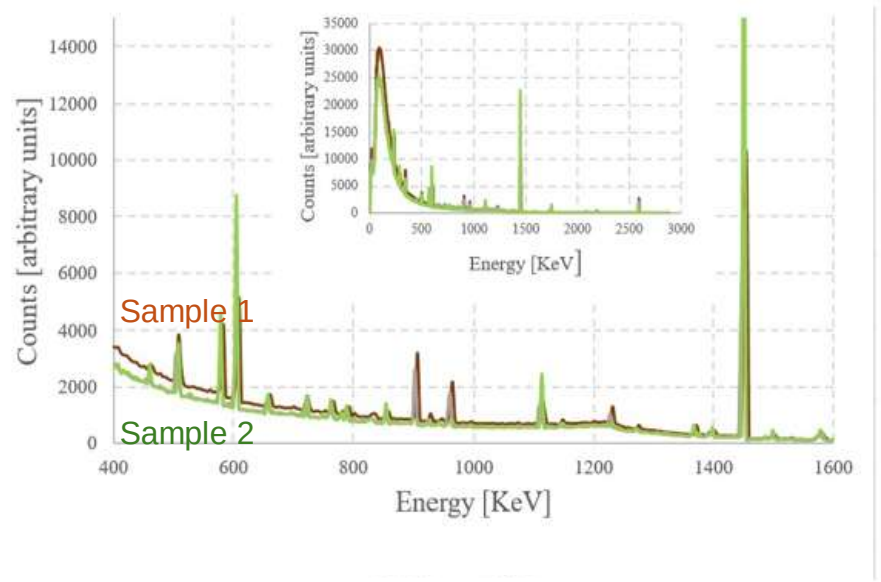
The differences that can be detected between similar soils are normally very slight.
These differences are usually related to the different nature of the sample being analyzed. For example, calcareous soils have very different gamma “signatures” than granitic or volcanic soils.

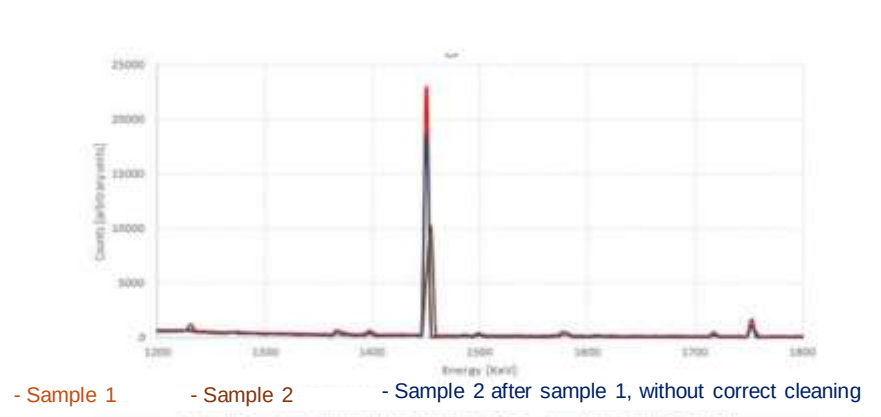
However, even in soils of the same type and nature, some isotopes may be more or less present in some soils, for geological, hydrogeological, or human-induced reasons. Measurable differences may occur locally.

Improper cleaning of sample holders, measuring instruments, containers or any other device used to acquire spectra can lead to erroneous or misleading results.

This point is completely generalizable to any type of analysis acquired during an OSI.

Gamma spectra of two chemically analogous soils from two distinct samplings. The inset shows spectra across the entire energy range.





- Sample 1 - Sample 2 - Sample 2 after sample 1, without correct cleaning

The figure shows an illustrative example of a gamma analysis of two similar soils, but with detectable differences, measured sequentially.

The correct sequence of cleaning and handling of all parts is fundamental and crucial.

If the cleaning operations are performed correctly, the two spectra are different.

If the cleaning is performed superficially, traces of sample 1 may remain in the sample holder during the measurement of sample 2, resulting in an altered and incorrect signal. In particular, the peak is more intense.

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Necessity of “good practices” protocols

1. Sampling Planning

- Defining objectives and protocols: clarifying the purpose of the survey and reference standards (ISO, UNI, EPA, etc.).
- Choosing sampling points: statistical and logistical representativeness of the site.
- Evaluating environmental conditions: seasonality, weather, possible sources of interference.
- Preparing forms: sampling sheets, chain of custody, authorizations

2. Instrument Status and Calibration
- Pre-use inspection: check the integrity, cleanliness, and functionality of probes, pumps, drills, etc.
- Traceable calibration: performed according to manufacturer specifications and documented.
- Preventive maintenance: planned schedules to avoid instrument drift.
- Consumables: ensure they are compliant and not expired (filter membranes, reagents, etc.).

3. Preparation and use of containers
- Material suitable for the matrix: glass, plastic, Teflon, etc., depending on the substance being analyzed.
- Pretreatment: washing, sterilization, or conditioning (e.g., acidification for metals).
- Sealing and labeling: clear and indelible for identification and traceability.
- Protection from contamination: use clean gloves and handle in a protected area if necessary.

4. Sample Collection and Storage
- Respecting timelines: minimize the interval between sampling and analysis.
- Storage conditions: refrigeration, protection from light, or freezing, depending on the matrix.
- Safe transportation: insulated containers, minimizing vibration and shock.
- Metadata recording: date, time, GPS coordinates, environmental conditions.

5. Laboratory Analysis
- Incoming inspection: Verify sample integrity and correct labeling.
- Standardized procedures: Validated and reproducible methods.
- Blanks and control samples: to monitor contamination and accuracy.
- Repeatability and replicates: to assess the precision of results.

6. Quality Control and Traceability
- Complete chain of custody: continuous documentation from collection to reporting.
- Internal audits: periodic checks throughout the process.
- Data traceability: storage of raw and processed results.
- Corrective actions: rapid and documented identification of non-conformities.

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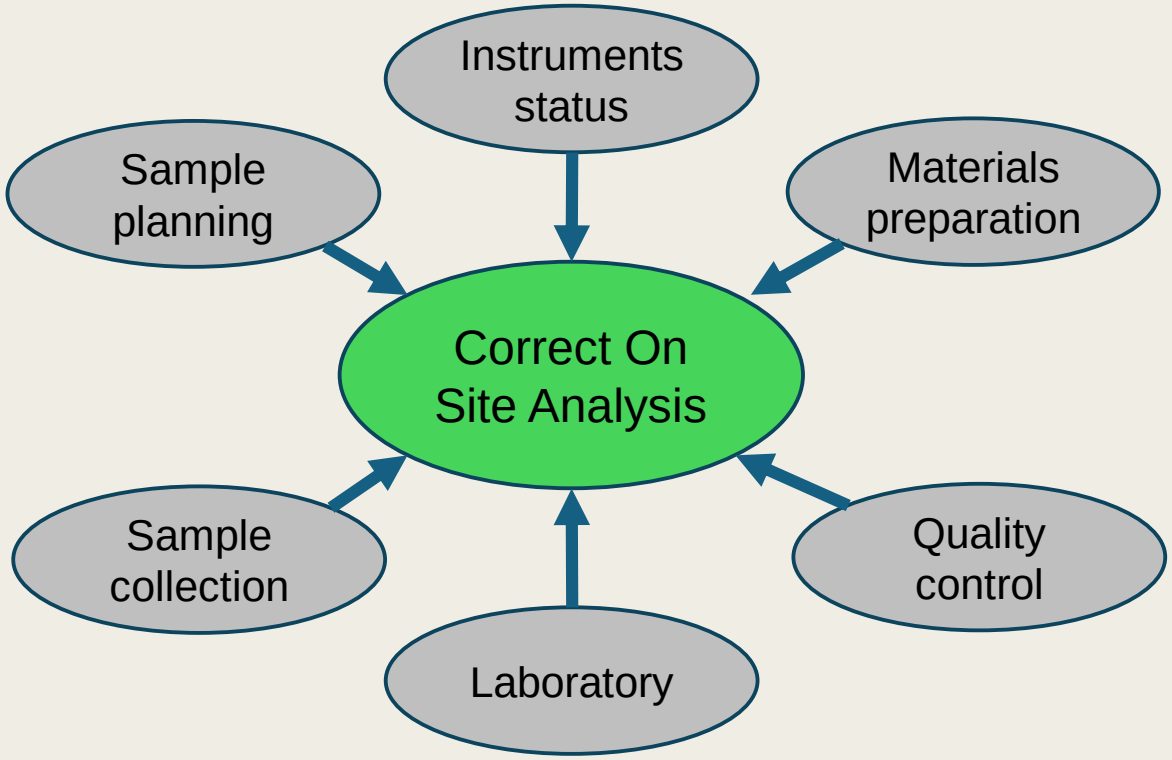
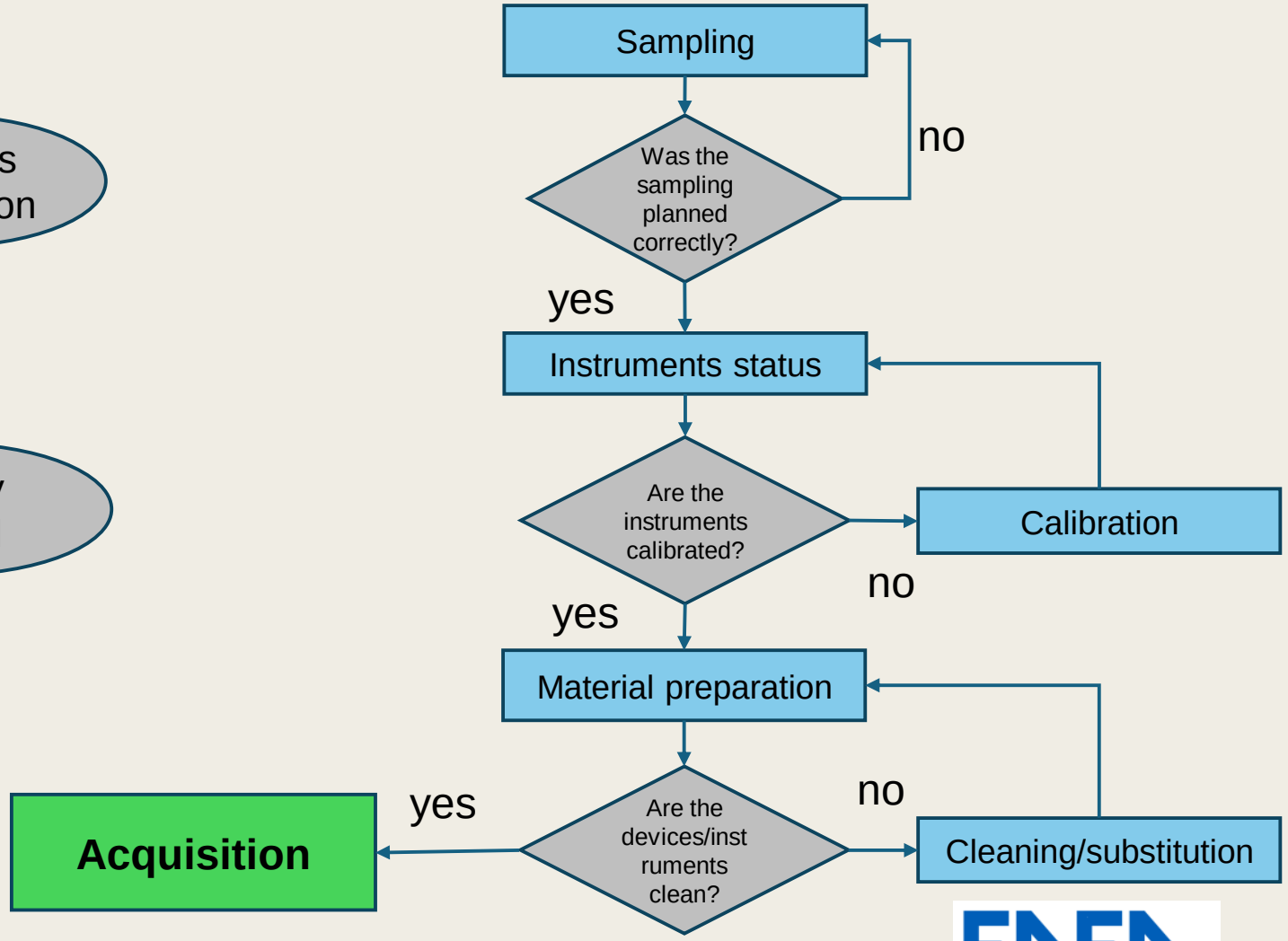
OSI Analysis Framework



OSI analysis flowchart



Conclusion

OSI analyses can only be conducted effectively in the right quality context and with an appropriate work framework. Contamination is possible and must be avoided with the right work protocol.