Mobile Unit for Site Characterization: Results of a Demonstration Event

Román Padilla Alvarez
Nuclear Spectrometry and Applications Laboratory
Department of Nuclear Sciences and Applications,

Horst Monken Fernandes
Waste Technology Section, NEFW
Department of Nuclear Energy

International Atomic Energy Agency

11/11/2011

NSAL: Nuclear Spectrometry and Applications Laboratory

Mission: Assisting Member States in introducing and extending the use of nuclear instrumentation and radiation spectrometry techniques

- Training
- Research aimed to improve analytical performance and to extend applicability (Adaptive Research)
- Provision of analytical services (MS and other IAEA units)
    - *Collaboration with NEFW section*

Outline:

- Scope of the exercise
  - Participants
  - Selected site
- Description of the used techniques
  - Measurement instruments
  - Data representation
- Results and conclusions

Scope of the exercise

- Follow-up of one of the recommendations of a previous Consultancy Meeting (Vienna, 29 Nov-3 Dec 2010) that compiled a list of available techniques for in-situ analysis.

  ⇒*"A demonstration exercise could serve to make an initial assessment of the capabilities of different techniques in a site suspected to present some radiation hazard"*

  - Such site should be either: a site contaminated by naturally occurring radioactive materials (accumulation of NORM due to past mining and/or milling activities); a site contaminated by nuclear and/or radiological accidents; or a military test site.

Participants:

Full name	Institution
Marcos C. Ferreira Moreira	IRD-CNEN, Rio de Janeiro, Brazil
Didier Dubot	CEA, Fontenay aux Roses, France
Thomas Streil	SARAD GmbH, Dresden, Germany
Gert Liebenberg	NECSA, Pretoria, South Africa
Robert Meyer	Tetra Tech Inc., Colorado, USA
Horst Monken Fernandes	Waste Technology Section, NEFW, IAEA, Vienna,Austria
Roman Padilla Alvarez	Nuclear Spectrometry and Applications Laboratory, NAPC, IAEA, Seibersdorf, Austria

Host: SARAD GmbH, Dresden, Germany

- Discussions were hosted at the facilities of SARAD GmbH
- SARAD provided support for all the organizational arrangements in Dresden.

Selected site:

60 x 110 m
Current use:
- sport field

Intended use:
- Building a kindergarten

The area is suspected to be affected by past mining activities. Waste rock or slag materials containing NORM were supposedly used to fill-in the terrain

Measured radiation hazards:

- Soil gas radon / thoron activity concentration
- Radon activity concentration in aerosols
- Dose rate (gamma scintilliation detector)
- Gamma emitting radionuclides activity concentration in soil

Measurement techniques / instruments:

- Soil gas radon / thoron activity concentration

Unit SARAD RT-1688

- air pressure, temperature and humidity sensors,
- built-in flow regulated pump
- spectrometer to process the measured signal.
- 4 measurement chambers, each one containing a 2 cm^2 ion implanted silicon detector.
- Measurement time 15 minutes
- Radon: ^{218}Po ($T_{1/2}$ = 3.1 m, E = 6.115 MeV)
- Thoron: ^{216}Po ($T_{1/2}$ = 0.145 s, E = 6.906 MeV)

Measurement techniques / instruments:

- Soil gas radon / thoron sampling probes (large volume)

Hand drilling set with gravel head,
packer probe
alternative machine drill and generator

Measurement techniques / instruments:

- Sampling procedure (large volume probe)

1) A hole is made with the hand-operated drilling systems and,

2) the packer probe is introduced into the hole.

Measurement techniques / instruments:

- Sampling procedure (large volume probe)

3) The packer probe is kept inside the hole and the packer sealing is inflated with a small hand pump.

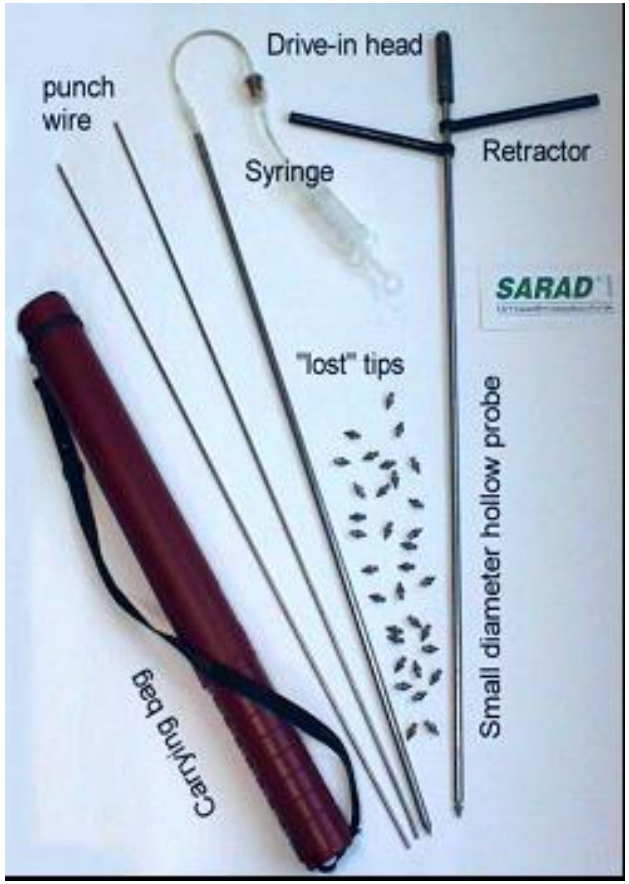
Measurement techniques / instruments:

- Sampling procedure (large volume probe)

4) The packer probe's tube is connected to the instrument's inlet and the measurement is started.

Measurement techniques / instruments:

- Soil gas radon / thoron sampling probes (small volume probe)



Measurement techniques / instruments:

- Sampling procedure (small volume probe)

1) The hollow probe (with attached sharpened disposable tip) is punched into the ground.

Measurement techniques / instruments:

- Sampling procedure (small volume probe)

2) The punch wire is inserted into the hollow probe, so the sharp tip can be pushed out and a small sampling volume is formed.

Measurement techniques / instruments:

- Sampling procedure (small volume probe)

3) The punch wire is extracted

Measurement techniques / instruments:

- Sampling procedure (small volume probe)

4) The radon measurement instrument is connected and the measurement cycle (integration time 5 minutes, measurement time min. 15 minutes) is started

Measurement techniques / instruments:

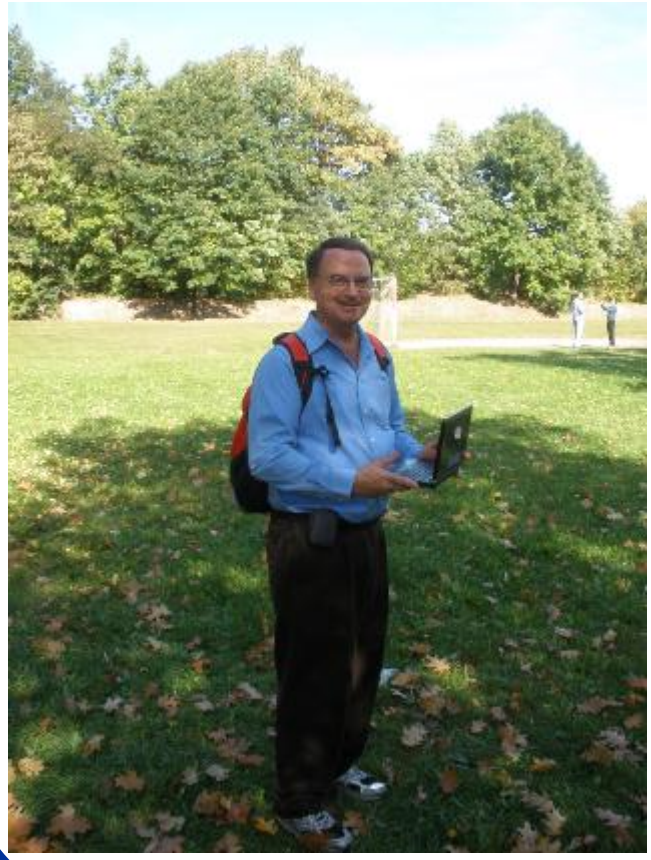
- Radon / thoron activity concentration in aerosols

Multipurpose unit A2M-4000

- air pressure, temperature and humidity sensors,
- built-in flow regulated pump
- 3 built-in spectrometers to process
  - soil gas activity measurement made with 4 chambers with 2 cm^2 ion implanted silicon detectors.
  - Alpha and beta measurements of aerosols using an arrangement of a 4 cm^2 filter and 2 ion implanted silicon detectors
  - Input (3rd channel) to connect a NaI detector

Measurement techniques / instruments:

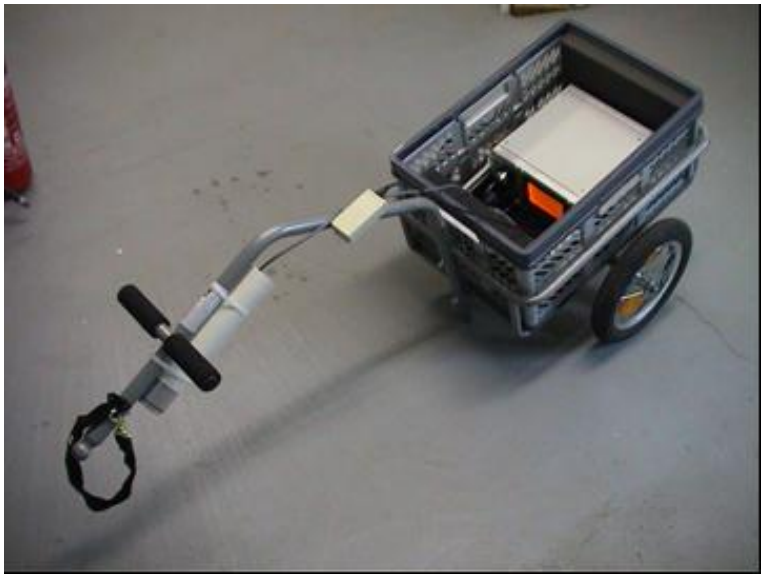
- (Gamma) Dose rate measurement at 1 m above the soil surface using a back pack system (Tetra Tech Inc.)



- 2” x 2” NaI(Tl) detector (Ludlum 44-10),
- A counting unit recording total counts (Ludlum 2350-1)
- GPS sensor (GlobalSat BU-353) with enabled WAAS and EGNOS capabilities, thus providing improved accuracy in positioning (± 2 m).
- A portable computer with dedicated software allowing collecting the measurement result and the GPS coordinates every second.
- Measurement time 1 s
- Walk pace ~ 1 m/s

Measurement techniques / instruments:

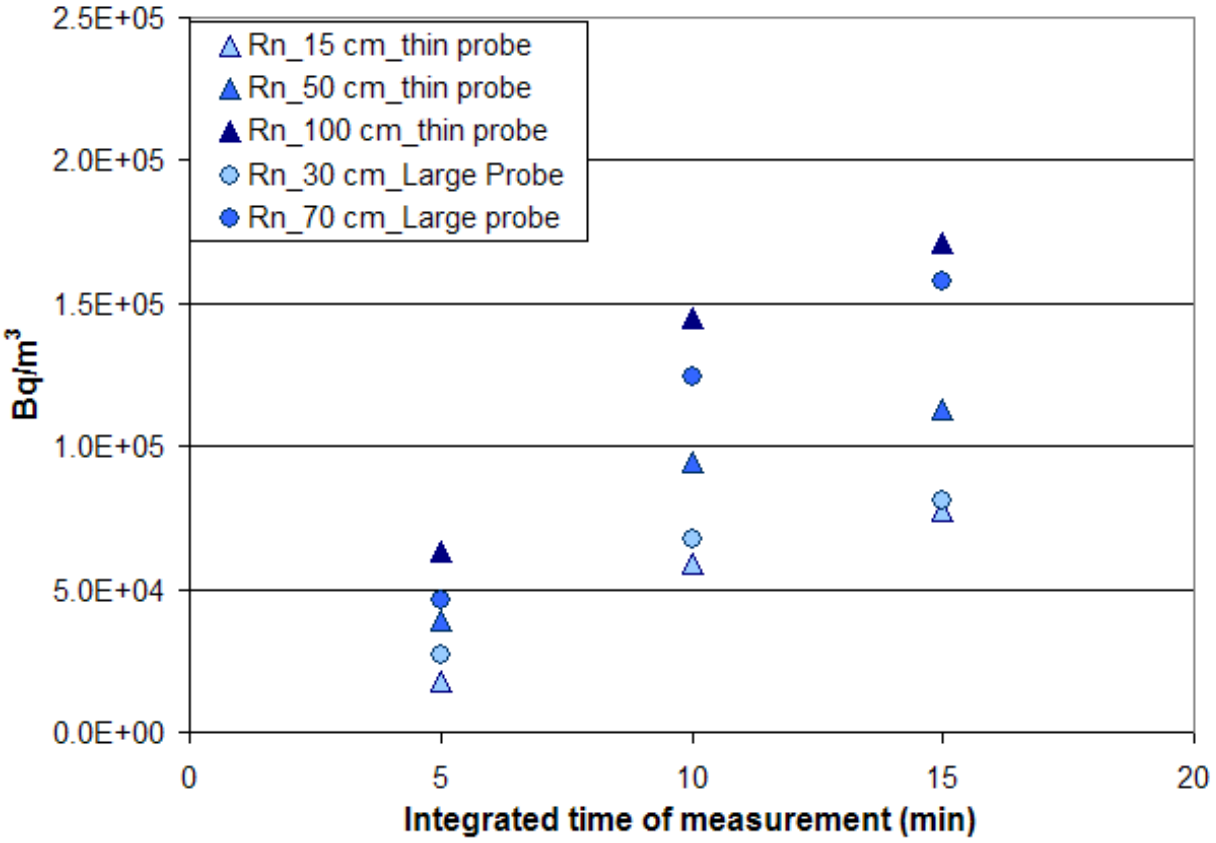
- Gamma spectrometry measurements using a transportable system (SARAD)



- 2” x 2” NaI(Tl) detector,
- A2M4000 multipurpose unit
- Measurement grid 10 x 10 m pattern
- GPS sensor.
- A portable computer with dedicated software allowing collecting the measurement result and the GPS coordinates.
- Measurement time 60 s

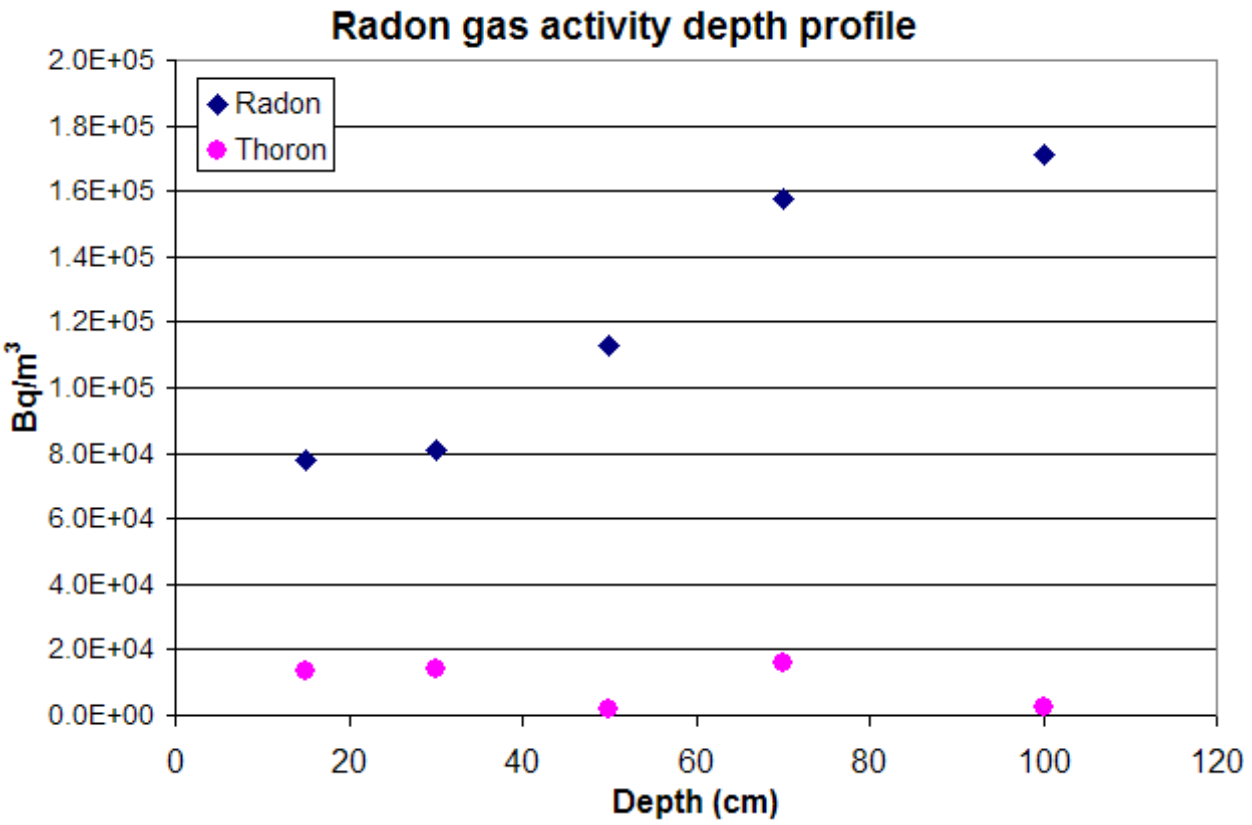
Results: Radon activity in soil gas

- Measurements using two different sampling probes



Results: Radon activity in soil gas

- Change in activity vs. depth

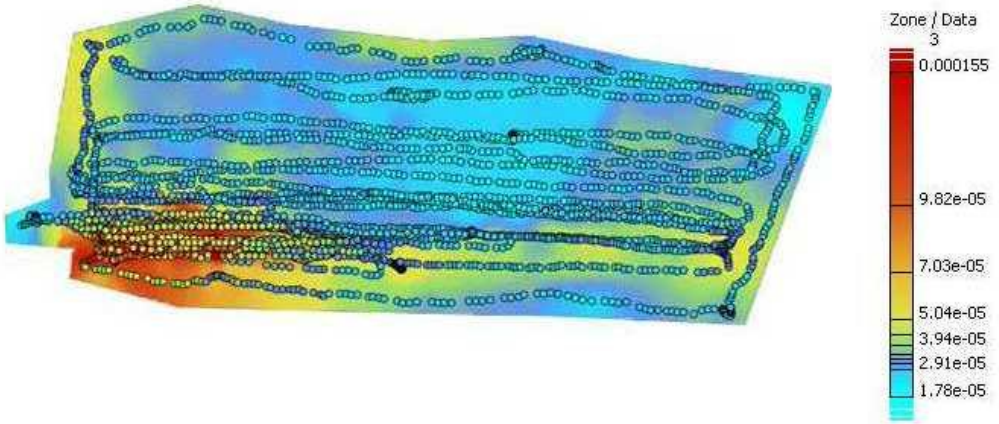


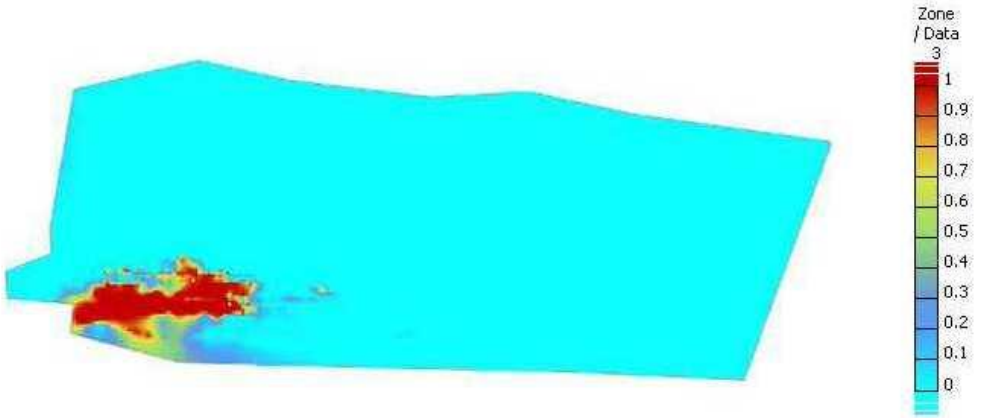
Results: Dose rate measurements using backpack system

- Representation as colour-coded plot of the dose rate (uR/h) data in a geo-referenced map

Results: Dose rate measurements using backpack system

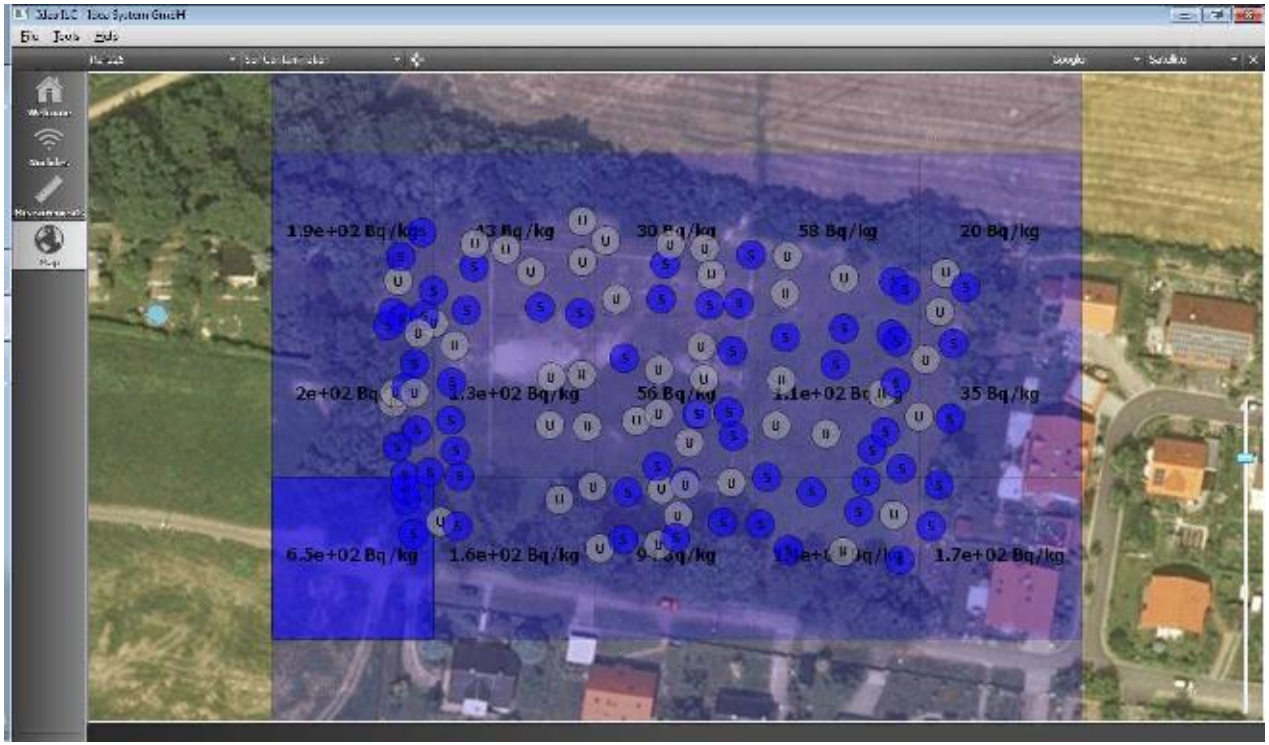
- Interpretation of the dose rate (R/h) measurements with Kartotrak (Geovariances, CEA)





Results: Gamma activity concentration measurements

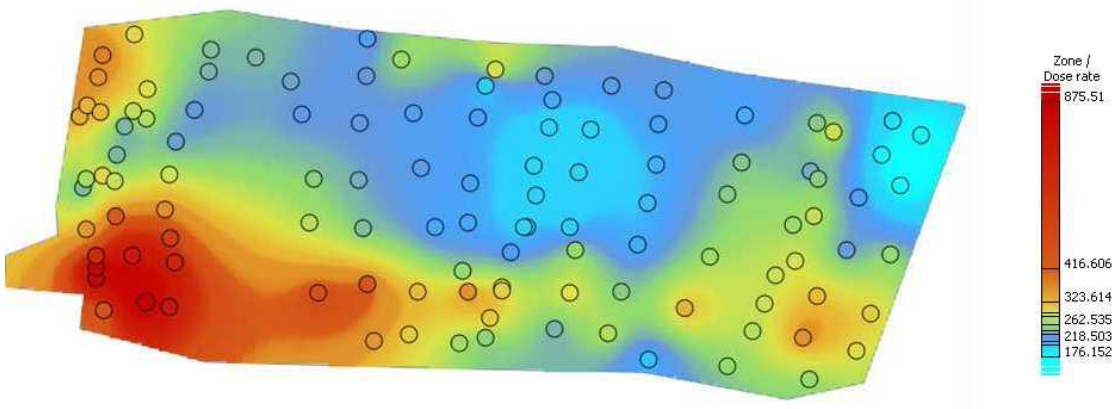
- Interpretation with IDEA ILC software (SARAD)

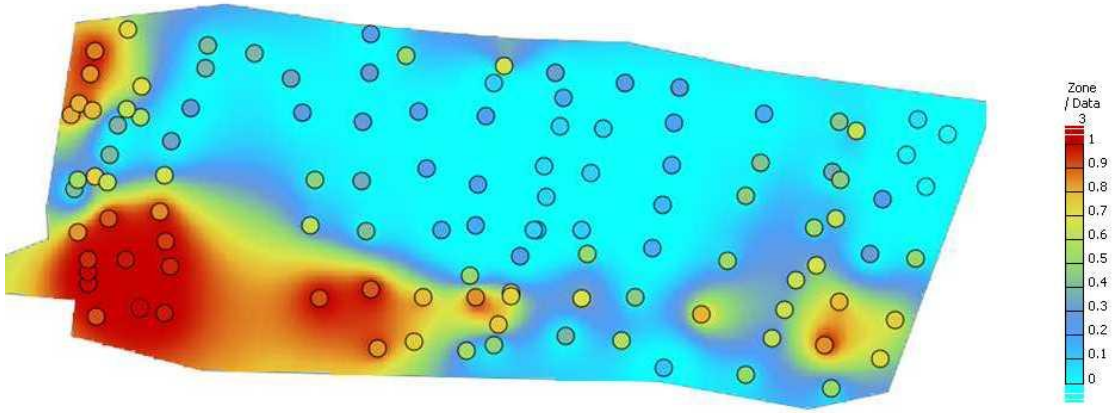


using a retrospective algorithm the average ^{226}Ra mass activity (Bq/Kg) is calculated for sections of the measured site area

Results: Gamma activity concentration measurements

- Interpretation of the activity concentrations (Bq/kg) results with Kartotrak (Geovariances, CEA)





Conclusions:

- Radiological characterization must comprise different types of measurements
- Sampling design as well as the interpretation of the measurement results depend on local specific safety regulations, on the intended use of the site after remediation, and on the foreseen method of containment or removal of the contaminants
- Gamma measurements carried out to reveal a surface distribution pattern mainly reflect the near surface contamination, and are influenced by the density of the soil, the energy of the measured radiation and cannot be used as a direct indication on the amount and depth distribution of the contamination.

Conclusions:

- Short interval dose rate measurements while moving along the terrain are useful to achieve a fast screening of the near surface contamination and to locate areas with increased radiation levels. Such information is of extreme value to decide which type of measurements and sampling to be performed for radionuclide identification and concentration activity estimation

- Discrete Gamma spectrometry measurements at points of a given sampling plan are useful to identify gamma emitting radionuclides in a cost-effective way.

- Additional depth profile measurements are required to gather data allowing modelling the distribution in depth, which is in turn valuable to optimize the volume of material to be removed or to optimize containment design and elements.

Conclusions:

- Radon and thoron measurements are required to determine the hazards for inhalation in the case of pollution with NORM.
- There is a need to compare the performance of other type of gamma detectors and sampling heads. For example, probes for bore-hole analysis can be useful for soil depth profile studies, whereas special sampler designs could be useful for measuring activity concentration in water bodies at different depths.
- The Kartotrak areal representation of the dose rate results gathered by using two different measurement methodologies are comparable. The continuous dose rate measurements provide a fast screening, whereas the grid gamma spectroscopic measurements could be used to create areal distribution of radionuclides.

Recomendations:

- There is a need to compare the performance of other type of gamma detectors and sampling heads. For example, probes for bore-hole analysis can be useful for soil depth profile studies, whereas special sampler designs could be useful for measuring activity concentration in water bodies at different depths.

- A comparison of the performance of different statistical approaches for interpretation of the results is required. Such evaluation shall be made for data sets representing different types of contamination.

- to organize a consultancy meeting in a venue not distant from a location that could be used for such comparisons, preferably during spring or summer season.

Thanks for your time and attention…