The Ninth International Symposium on Naturally Occurring Radioactive Material
Denver, Colorado | 23-27 September, 2019

Remediation of Uranium Mining Legacy in Portugal

Fernando P. Carvalho
Laboratório de Protecção e Segurança Radiológica (LPSR),
Instituto Superior Técnico/ Universidade de Lisboa
Portugal
E-mail: carvalho@itn.pt

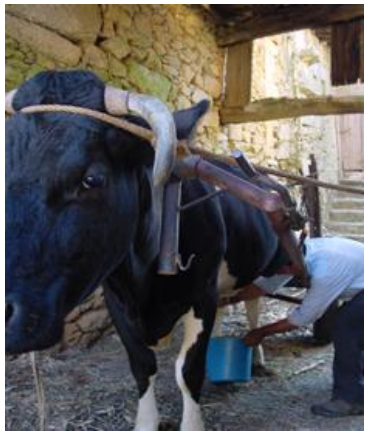
Legacy of radium and uranium mining in Portugal

- Mineralizations of Uranium in the centre-North of Portugal (region of Beiras)
- 60 deposits exploited from 1908-2001

Radionuclide determinations

Analysis of samples

Food, drinking water, air, soil, rivers



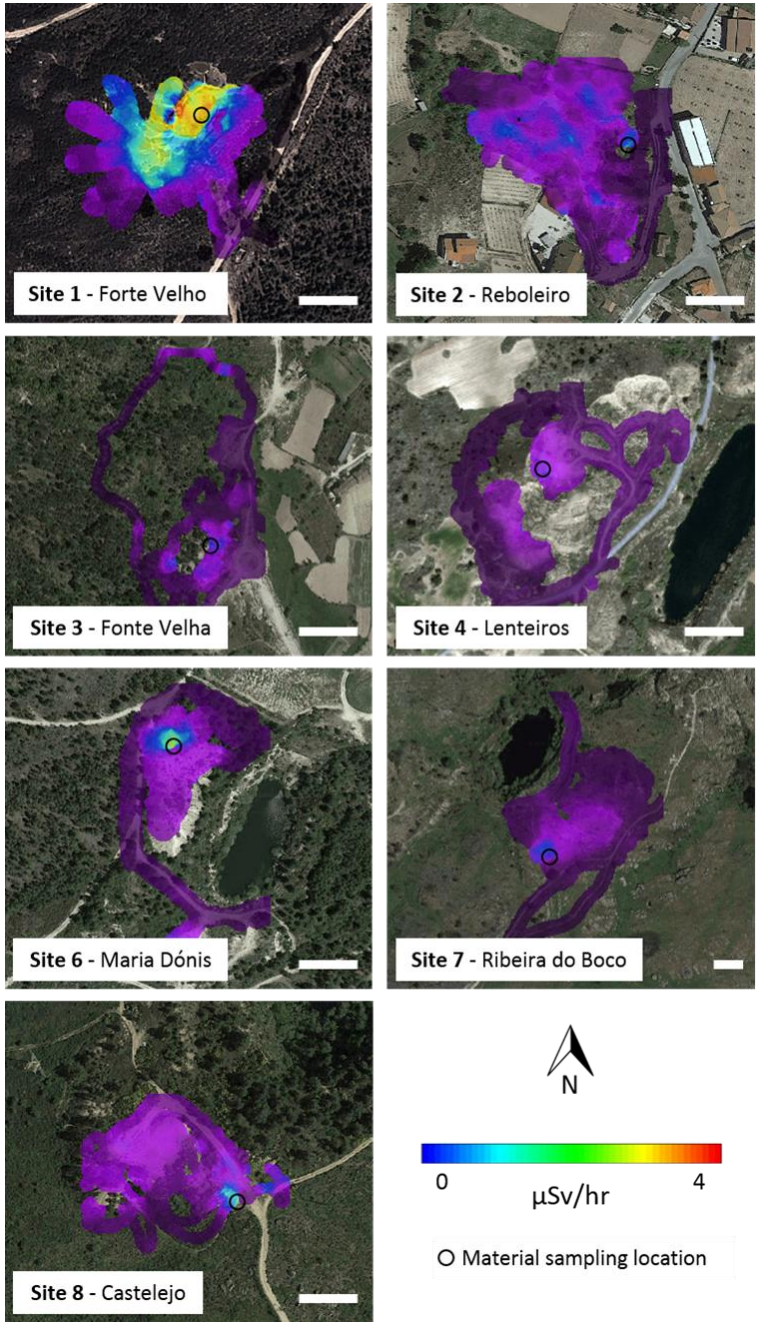
- Concentrations (Bq/kg)

Measurement of Ambient dose rates

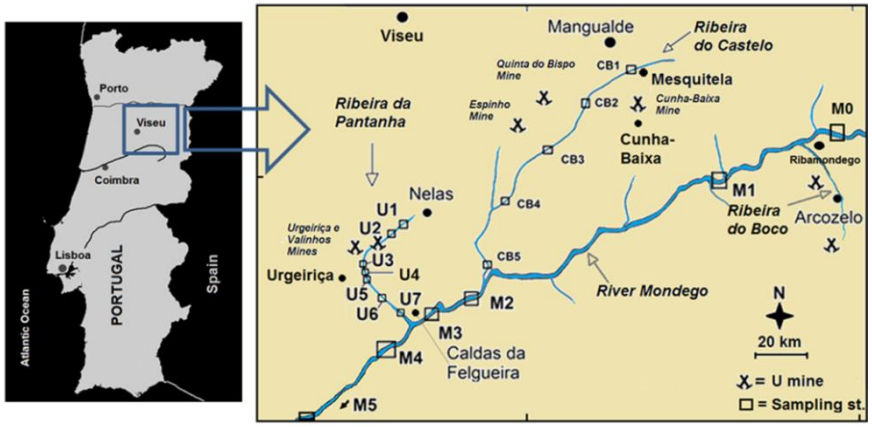
aerial survey with a drone

Forte Velho, Guarda

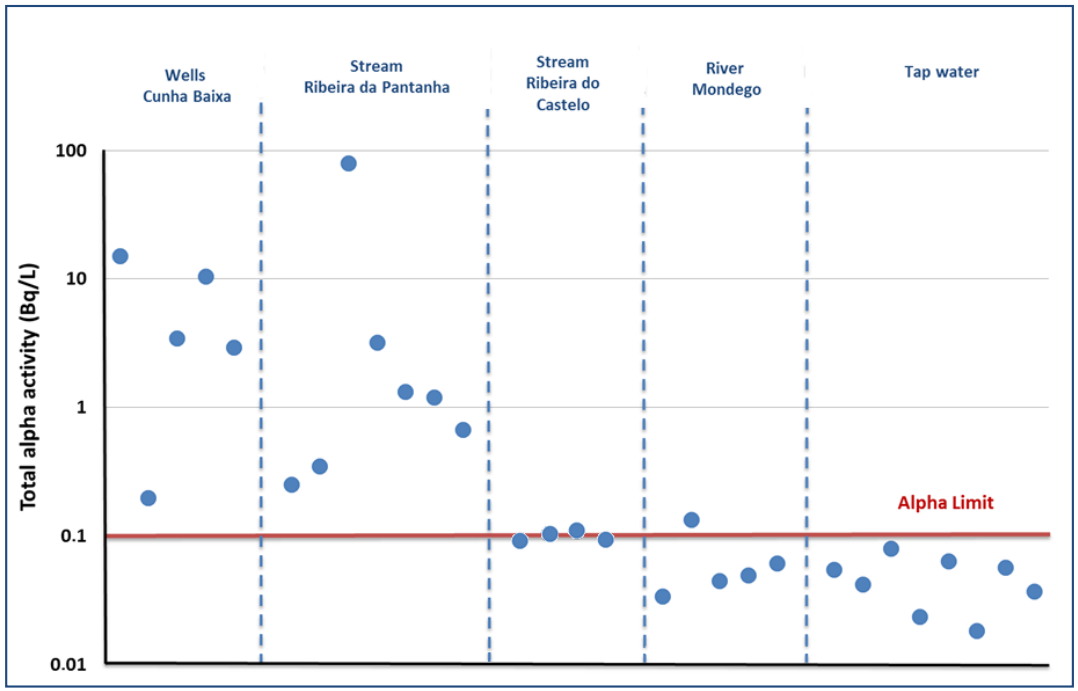
External dose on some tailings: 30 mSv/year



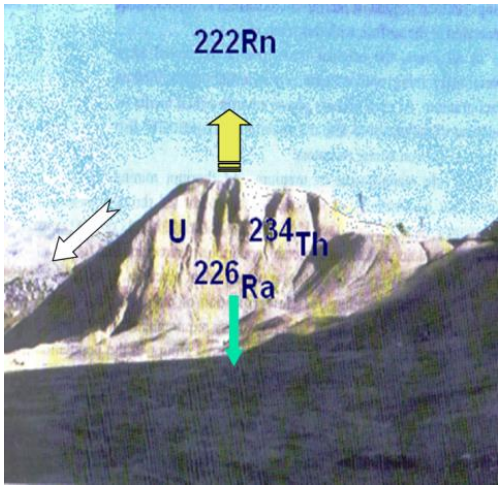
Radioactivity in surface waters



Aguieira dam in river Mondego



Environmental remediation



- **Approved by the Government**
- **Implemented by the mining company holding EDM- started in 2005**

- **Goals:**
  - **Confine the milling tailings**
  - **Concentrate mining waste in 4 disposal sites**
  - **treat the acid mine waters**

Aerial view of Urgeiriça (early 2008)

Decontamination of facilities

Industrial areas of uranium milling were cleaned:

- Removal ofcontaminaed pipes, sewers and soil,
- Dust control during operations
- Radiation protection measures.

After decontamination, several buildings were allocated to other industrial activities.

Mining and milling waste recovery

Removal of waste at Forte Velho

Waste disposal in a former uranium mine pit

- There were many small mines
- Mining and milling waste were concentrated in a few places, disposed in duly prepared pits, and confined with multi-layer covers.

Clean sites released for public use

Several former mine sites (open pits) were monitored, cleaned, and re-shaped.

No significant contamination remained, and sites were considered adequate for public use as:

- Recreational areas
- Mine museum
- Water reservoir for fire-fighting

Mine water: chemical treatment

Mine water drainage:

- Generally acid
- Contains stable metals (Ar, Bi, Y, Cu, Pb, …)
- Often in high concentrations
- Contains dissolved and particulate radionuclides (U, Th, Ra, Rn, Pb, Bi,…)

Chemical treatment:

- Addition of $BaCl_2$,
- addition of hydroxide to increase pH to 8-9,
- Co-precipitate stable metals and radionuclides
- Before releasing treated water

Mine water: treatment by plants

Mine drainage:

- Pumped into a sequence of ponds with plants (*Typha*) growing
- Growing plant biomass accumulates stable metals and radionuclides
- Water parameters checked before release of treated water into streams
- Plant biomass incinerated and disposed as rad waste

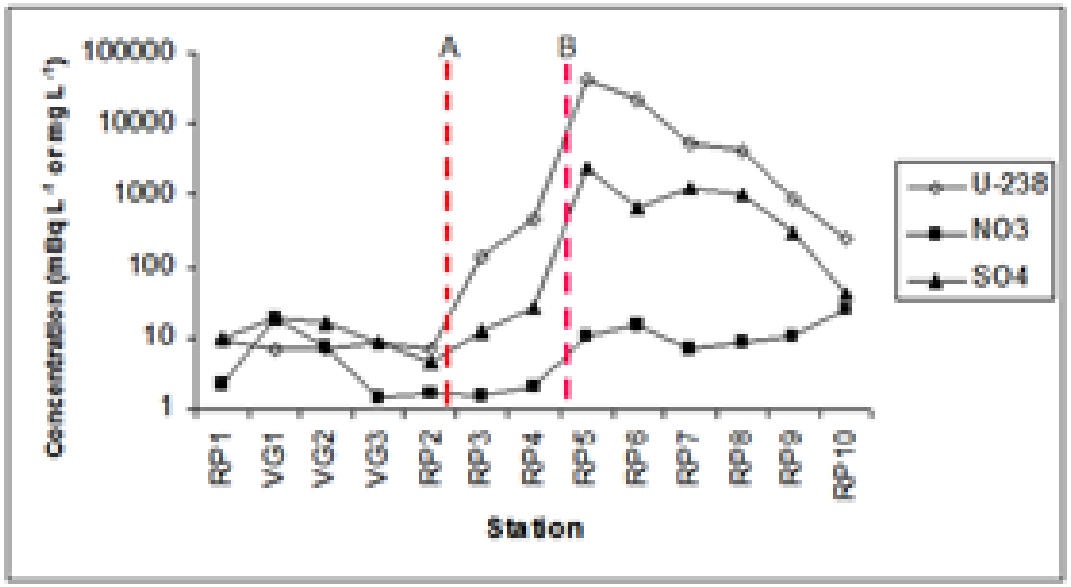
Alternative water supply

In a valley near Cunha Baixa mine:

- Uranium mine was on hills' slope above village and agriculture valley
- Aquifer was contaminted by acid from in situ leaching in the mine
- In the valley, water from wells became acide and contaminated with radionuclides (226Ra)
- Wells were sealed.
- Surface water reservoir built on top of the hills to provide clean water for irrigation in the valley.

Water courses decontamination

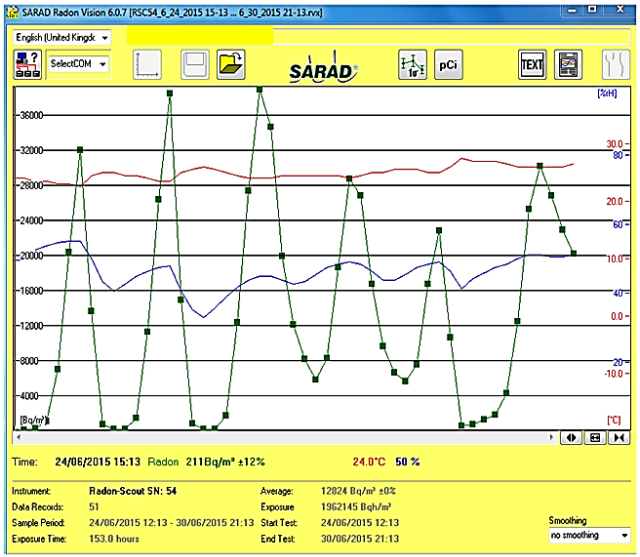
Milling tailings with the cover in place, at Urgeiriça. In the first plane, the stream Ribeira da Pantanha after clean up and reconstruction of the stream bed.



Contamination of Ribeira da Pantanha water before remediation.

Radon monitoring

- Radon measurement indoors and outdoors in the uranium mining region.
- Regardless of radon origin, the maximum concentration today is 300 Bq/m^3 (annual average).
- High radon concentrations can be due to mining waste used, but also of natural origin.



Old houses: remedial action

Because of materials available from mining (sand, gravel, blocks),In the past were used in

- Road paving
- House construction
- Filling material.

- Radiological assessments made. Issues: external exposure and high radon indoors
- Remedial action in houses of miners quarters undertaken: reconstruction of some walls.

Environmental restoration as part of uranium production

- **There are uranium deposits to exploit**

- Public perception of risks
- Regulators: *Mining licenses* and permits
  - Conformity with new ICRP recommendations and dose limits:
  - Protection of non-human biota
- Public: «*Social license*» !
  - Trust, acceptable impact, post-extraction rehabilitation
- Costs that must be incorporated in uranium production costs
  - Environment protection
  - Radiological protection of workers and public (1 mSv/y dose limit)
  - Rehabilitation of sites

Conclusions

- Legacy of radium-uranium waste (NORM waste) was of radiological concern
- Public perception of the radiation risk was correct
- Risk assessment was the basis for sound environmenral remediation work
- Contamination and radiation exposure were abated and results are visible
- Social tranquility and public trust were regained.

Thank you for your kind attention !

Fernando P. Carvalho
e-mail: carvalho@itn.pt