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Laboratory for **A**ccelerator **B**ased **S**ciences

MANUS 2009 Practical:

Gamma-ray spectrometry in the Environmental Radioactivity Laboratory

2009

** iThemba LABS is a national facility of the National Research Foundation which is funded by the Department of Science and Technology.*

Introduction

The Department of Nuclear Physics operates the Environmental Radioactivity Laboratory (ERL). The ERL staff conduct research into the levels of radioactivity (natural and anthropogenic) in the environment. The main experimental techniques used are in-situ and laboratory-based gamma-ray spectroscopy. The in-situ measurements are made using a MEDUSA (Multi-element Detector for Underwater Sediment Activity) detector system (fig. 1). The laboratory-based (high-resolution) measurements are conducted using a hyper-pure germanium detector (HPGe) which is encased in a 10 cm thick lead castle in order to reduce the room background (fig. 2).

The current focus is on the measurement of activity concentration of (primordial and anthropogenic) radionuclides in soils, sediment and water. Current research topics include: the exhalation of radon (an inert radioactive gas) from mine tailings dams, the correlation between radon levels in domestic dwellings and source terms (soil, building material), studies into the potential use of radiometry to partially characterize the terroir associated with vineyards, applications of radon in hydrogeology, the systematic effects that impact on the measurement of activity concentrations, Monte Carlo simulation of the interaction of gamma-rays with detectors (for our geometries), the use of naturally occurring radioactivity to optimize minerals processing, studies of the impact of environmental radioactivity on ecosystems.

The research is conducted in collaboration with South African universities (in particular the University of the Western Cape), local industrial/agricultural sectors and the Nuclear Geophysics Division at the KVI (University of Groningen, the Netherlands).

The ERL is currently busy implementing an ISO17025 laboratory quality management system.

Fig.1 : MEDUSA detector mounted on a 4x4 vehicle during an in-situ mapping campaign.

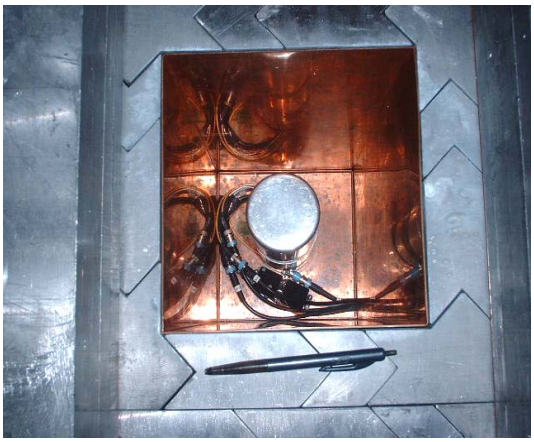

Fig.2 : Inside of lead castle showing the top of the ERL HPGe detector.

Aim and objectives of practical

- To learn about environmental radioactivity measurements using gamma-ray spectrometry (low-background configuration)
- To learn about the determination of absolute gamma-ray detection efficiencies
- To determine anthropogenic activity concentrations in a dam sample from iThemba LABS
- To learn about radiation safety risk assessment

Demonstrators: Richard Newman, Israel Hlatshwayo, Paulus Masiteng

Equipment needed

- High-purity germanium detector encased in 10 cm thick lead castle
- Palmtop Multi-channel analyser + manual
- Screw-top Marinelli beakers (empty)
- Liquid source (Marinelli geometry) + copy of source certificate
- Thorium reference source (Marinelli geometry)
- iThemba LABS dam water sample
- Electronic dosimeter
- **Own laptop computer (for data analysis) preferred**

Tasks

- Familiarize yourself with HPGe detector system. Load Palmtop software onto your computer.
- Calibrate the system using the Th reference source (30 minute measurement). Note calibration coeffients and save spectrum.
- Measure liquid source (1 hour) – save spectrum.
- Measure dam water (screw-top Marinelli) (overnight measurement)
- Determine the source composition of the liquid source
- Now use the liquid source certificate and spectrum to determine the absolute detection efficiency as a function of gamma-ray energy. For this select at least 5 prominent gamma-ray lines from about 120 keV to 1410 keV. Use Excel and the following parameterization: $a(E/E_o)^b$, where a and b are constants and E is the gamma-ray energy (in keV) and E_o = 1.0 keV.
- Identify as many anthropogenic radionuclides present in the dam water as possible and determine the activity concentration of two of these (also quote uncertainty based on counts measured). You will be given a background tap water spectrum measured with using the same configuration.
- Identify one set of single and double escape peaks in your source spectrum – justify your answer.

- For bonus marks: make a limited risk assessment based on your dam findings (consider only one anthropogenic radionuclide and conside ingestion dose only).

Deliverables

- A comprehensive report on your practical. **This must be written up on a word processor and sent to me by e-mail a week after completion of your practical.**
- Include in your report sections on: aims/objectives, methods (include photos, electronic diagrams including module names and settings, table of energy calibration coefficients etc.), results (include spectra, efficiency curves, tables etc.) and discussion, summary and conclusion.

Notes

1. Refer to hand-out for further information.
2. Marking scheme: Total marks for practical: 50 (30 marks for results and accuracy, 20 marks for report layout and presentation).
3. Quote all result with at least 3 significant figures.
4. Please do not disclose your results and/or show your prac write-up to other prac pairs until all pracs are assessed. **Direct copy between prac groups can lead to both prac groups getting zero for the practical.**

References

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