IS 03 Measurements and Applications of Radionuclides in the Marine Environment

Course Objectives

The primary objective of this "Spring Summer Course" is to provide students with the knowledge and tools necessary to master low-level counting (LLC) techniques. These techniques enable the detection, quantification, analysis, and interpretation of very low concentrations of both natural and artificial radionuclides in various types of environmental matrices (e.g., water, soil). Additionally, the course will explore practical applications of radionuclide measurements in the marine environment and the implications that precise radionuclide determination has for radiological and environmental safety.

Course Content and Schedule

GENERAL CONCEPTS IN RADIOACTIVITY AND TYPES OF DETECTORS

- **ALPHA SPECTROMETRY**
  - Fundamentals of the technique
  - Radionuclide isolation
  - Preparation of thin sources: electrodeposition and micro-precipitation
  - Practical application of the technique: measurement of uranium and polonium isotopes, and their isotopic ratios in sediment and water samples.
  - Evaluation of radiological dose.
- **GAMMA SPECTROMETRY**
  - Fundamentals of the technique
  - Calibration of a semiconductor spectrometer
  - Calculation of activity concentration
  - Practical application of the technique: measurement of natural and artificial gamma-emitting isotopes (226Ra, 228Ra, 40K, and 137Cs) in sediment and water samples.
- **TOTAL ALPHA AND BETA ACTIVITY**
  - Fundamentals
  - Applicable regulations for radioactivity monitoring
- **PRACTICAL APPLICATIONS OF RADIONUCLIDE MEASUREMENTS IN THE MARINE ENVIRONMENT**
  - Dating
  - Carbon flux
  - Radiological monitoring of water
- **EVALUATION** (1-hour in-person session)

SCHEDULE

MONDAY, JULY 7: GENERAL CONCEPTS, TYPES OF DETECTORS, THEORY (Professor: IRL)

09:00-10:00 - Opening and Welcome Breakfast
10:00-14:00 - **Fundamentals of Radioactivity Measurement**

- Basic concepts

- Radioactive decay law
- Natural radioactive series
- Artificial radioactivity
- Radiation-matter interaction: heavy charged particles, electrons, photons, neutrons

Detectors: General Properties

- Counting statistics
- Simplified model
- Operating modes
- Pulse height spectra and plateaus
- Energy resolution
- Efficiency
- Dead time: models

Choice of Detector

- Type of radiation
- Energy range
- Resolution
- Efficiency
- Counting rate

Types of Detectors

- Gas detectors: operation, modes, properties, and applications
- Scintillation detectors: operation, properties, and applications
- Semiconductor detectors: operation, properties, and applications

Electronics and NIM Modules

Visit to the Spectrometry Laboratory

- Background spectrum acquisition (gamma and alpha)

TUESDAY, JULY 8: ALPHA SPECTROMETRY (Professor: MGG)

09:00-14:00

- Explanation of the equipment and technique
- What is an alpha spectrum? Radionuclides of interest and alpha energies: RADDECAY
- How is the activity of the thin radioactive source calculated? Detector background and target
- Activity of the sample? Need to know chemical yield (tracer)
- Isotopic dilution method for measuring the concentration of a radionuclide and its uncertainty
- Detection limit

TUESDAY, JULY 8 (AFTERNOON): EXPERIMENTAL: RADIOCHEMICAL METHODS (Professors: FJSC/MGG)

16:00-18:00

- Explanation of the TBP or TRU Method (measurement of U-Po isotopes); general scheme
- Practical application:
    - Water traced with U, and Pb-210/Po-210
    - Measurement of U, Po-210 in sediments

WEDNESDAY, JULY 9: THEORY AND ANALYSIS OF GAMMA SPECTROMETRY SPECTRA (Professor: JPB)

09:00-14:00

- Explanation of the technique
- Calculation of radionuclide concentration and its uncertainty
- Detection limit
- Energy and efficiency calibration of photopeaks
- Practical considerations for low-activity samples
- Practical application: Calibration spectrum
- Efficiency calculation: Methodology, results, validation
- Sample pretreatment and/or pre-concentration: calcination, co-precipitation, evaporation, etc.
- Measurement geometry
- Radionuclides of interest (see IAEA Measurement of RNs in Food and the Environment)
- Place the sample in the detector and collect spectra (ORTEC)
- Spectrum processing and activity calculation
- Select 5 spectra to distribute with data and a good background spectrum
- Analyze the spectrum to identify radionuclides and energies
- Determine/calculate the necessary efficiencies
- Manually calculate photopeak areas: continuous background, gross area, and net area

WEDNESDAY, JULY 9 (AFTERNOON): CULTURAL ACTIVITY SPONSORED BY THE UNIVERSITY OF CÁDIZ

THURSDAY, JULY 10: INTERPRETATION AND ANALYSIS OF SPECTRA (Professors: FJSC/MGG/IRL)

09:00-14:00

- Experimental alpha spectrometry: Acquisition, interpretation, and analysis
- Experimental Gamma spectrometry: Analysis of spectra, intercomparison exercise

THURSDAY, JULY 10 (AFTERNOON): MEASUREMENTS BY ICP AND SCIENCE REQUIRING RADIONUCLIDE MEASUREMENTS (Professor: Michael Ketterer)

15:30-18:30

- Uranium Measurement by ICP
- Environmental laboratory: importance of radionuclides activities for science

FRIDAY, JULY 11: PRACTICAL APPLICATIONS OF RADIONUCLIDE MEASUREMENT (Professors: IRL, MGG)

09:00-11:00 - Total Alpha and Beta Activity. Radiological Water Monitoring (FMP).
11:00-13:00 - Carbon Flux (TBD)
13:00-14:00 - Dating (IRL)

14:00-14:30 - **Course Evaluation**

SATURDAY, JULY 12: TOURISTIC TOUR SPONSORED BY UNIVERSITY OF CÁDIZ