SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

P5.1-785

Radionuclide Detection Variation in Europe: A Comparative Analysis Using RN Toolkit

Carlos Eduardo Santos Bonfim[1], Edson Ramos de Andrade [2], Graziela Fernandes de Mello Bonfim[3], Begoña Pérez López[3],Celia Angelica Caveda Ramos[4]

1 Chemical, Biological, Radiological and Nuclear Defense Institute, Brazil
2 Military Institute of Engineering (IME), Brazil,
3 Artificial Intelligence Commission – Brazilian Bar Association (Rio de Janeiro Chapter), Brazil
4 Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Spain
5 Center for Radiation Protection and Hygiene, Cuba

INTRODUCTION AND MAIN RESULTS

This study assessed radionuclide detections (2021–2024) at eight CTBTO IMS stations. Particulates (DEP33, NOP49, RUP61, SEP63) showed Cs-137 and I-131 dominance with winter peaks. Noble gases (DEX33, NOX49, SEX63, RUX61) revealed persistent Xe-133 at low isotopic ratios. No evidence of nuclear explosions was found.

SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Radionuclide Detection Variation in Europe: A Comparative Analysis Using RNToolkit

Carlos Eduardo Santos Bonfim[1], Begoña Pérez López[2],Celia Angelica Caveda Ramos[3]

P5.1-785

Introduction

- Consolidated Report Scope
- Eight IMS Station
- Data Types: Particulates, Noble Gases
- Monitoring Period:2021-2024
- Objective: Identify Radioactivity Changes
- Sources of Change: Human Activities, Nuclear Incidents, Atmospheric Transport
- Insights: Regional Emission Dynamics, Seasonal Transport, IMS Resilience

Methodology

- Data Harmonization
- Categorization: Levels (1-5) and (A-C)
- Evaluations: Annual, Monthly Seasonality, Nuclide Categorization, Isotopic Ratios
- Particulate Analysis

  Natural Radionuclides: Be-7, Pb-212F;
  Others: Cs-137, I-131, Co-60, Nb-95, Ru-103/106, Mn-54, Ce-144, Na-24, Co-58, Am-241, As-74, In-115m, K-42, Ru-106, Sn-113, Y-91m, Zn-65, Cd-115m, Cr-51, Tc-99m, Ba-140
- Noble Gases Analysis
  - **Focus:** Xe-133 Histories, MDC and Abnormal Thresholds
  - **Isotopic Rations**: Xe-133/Xe-131m
- Metrics: Day with Detection ≥ , Seasonal Distributions, Screening Flag Exceedance

Results & Discussion

Particulate Station

DEP33 (Schauinsland, Germany)

- **Dominant Nuclides**: Na-24. Cs-137 and I-131;
- **Natural Nuclides**: Be-7, Pb-212F (Consistent);
- **Artificial Nuclides Freq:** Na-24 (124), Cs-137 (15), Co-60 (7), I-131 (4);
- **Seasonal Analysis:** Winter peaks, Mar 2024;
- Level ≥ 3 Trend: Decreasing (2021: 135, 2024: 64);
- **Cs-137 History:** Low concentrations (1-5.6 μBq/m³), below anomalous threshold;
- **Isotopic Ratios:** Na-24/Cs-137 (5), Na-24/Co-60 (6).

NOP49 (Spitsbergen, Norway)

- **Dominant radionuclides:** particularly Cesium-137 (Cs-137), Iodine-131 (I-131), and Cobalt-60 (Co-60);
- **Natural Nuclides:** specifically Beryllium-7 (Be-7) and Lead-212 Daughter Products (Pb-212F);
- **Artificial Nuclides Freq:** Cs-137 (9), Na-24 (5), Co-60 (2);
- **Seasonal Analysis:** Winter (Dec-Mar) peaks, arctic influence;
- **Level 4 Detections:** More frequent than DEP33, magnitudes below anomalous thresholds;
- **Isotopic Ratios:** Na-24/Cs-137 (2), K-42/Zn-65 (2) – Anthropogenic.

IDQBRN

SnT 2025 CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE

Radionuclide Detection Variation in Europe: A Comparative Analysis Using RNToolkit

Carlos Eduardo Santos Bonfim[1], Begoña Pérez López[2],Celia Angelica Caveda Ramos[3]

P5.1-785

Results & Discussion

Particulate Station

RUP61 (Dubna, Russian Federation)

- **Dominant Nuclides:** particularly I-131, Cs-137, Co-60, and Nb-95;
- **Natural Nuclides:** Be-7, Pb-212F (Consistent);
- **Artificial Nuclides Freq:** Cs-137 (68), I-131 (66), Na-24 (30);
- **Seasonal Analysis:** Winter (Jan-Mar) & Autumn (Oct-Dec) peaks;
- **I-131:** Most expressive (66 detections)
- **Isotopic Ratios:** I-131/Cs-137 (78), Na-24/I-131 (22) – Anthropogenic.

SEP63 (Stockholm, Sweden)

- **Dominant radionuclides:** Cs-137, I-131, Ru isotopes;
- **Natural Nuclides:** Be-7, Pb-212F (Consistent);
- **Artificial Nuclides Freq:** Cs-137 (56), Na-24 (6), I-131 (3);
- **Seasonal Analysis:** Winter-Spring, colder months;
- **Cs-137:** Highest frequency (50 days level ≥ 3), magnitudes below anomalous thresholds;
- **Isotopic Ratios:** Na-24/Cs-137 (5) – Anthropogenic.

Results & Discussion

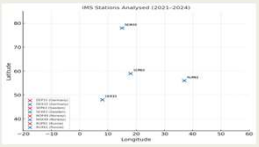
Noble Gas Station

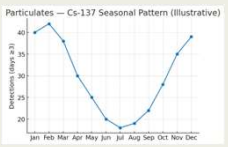
DEX33 (Schauinsland, Germany)

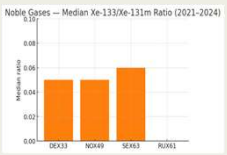
- **Tracked:** Xe-133 activity, Xe-133/Xe-131m ratios;
- **Valid Records:** 1433
- **Median Ratio:** 0.047;
- **Ratios > 1:** 38 cases (None above screening threshold);
- **Seasonal Analysis:** Moderate, reinforcement in colder months;
- **Xe-133 Detections:** Mostly below anomalous threshold;
- **Nuclides:** Xe-133, Xe-135, Xe-131m.

NOX49 (Spitsbergen, Norway)

- **Tracked:** Xe-133 activity, Xe-133/Xe-131m ratios;
- **Valid Records**: 2699;
- **Median Ratio:** 0.05;
- **Ratios > 1:** 78 cases (None above screening threshold);
- **Xe-133 Detections:** Regular, below anomalous threshold.







Results & Discussion

Noble Gas Station

RUX61 (Dubna, Russian Federation)

- Data incomplete for this cycle

SEX63 (Stockholm, Sweden)

- **Tracked:** Xe-133 activity, Xe-133/Xe-131m ratios;
- **Valid Records:** 4954;
- **Median Ratio:** 0.06 (Reported 0.268 in detailed report);
- **Ratios > 1:** 82 cases (None above screening threshold);
- **Seasonal Analysis:** Moderate, reinforcement in colder months;
- **Xe-133 Detections:** Mostly below anomalous threshold.

IDQBRN

SnT 2025 CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE

Radionuclide Detection Variation in Europe: A Comparative Analysis Using RNToolkit

Carlos Eduardo Santos Bonfim[1], Begoña Pérez López[2],Celia Angelica Caveda Ramos[3]

P5.1-785

Results & Discussion

- Comparative Analysis
- Particulate Stations: Seasonal transport, fallout, Cs-137 & I-131 dominant
- Noble Gas Stations: Real-time emissions, persistent low-level Xe-133 releases
- Combined View: Radionuclide dispersion, transport, source attribution
- No Nuclear Explosive Events Detected

Conclusion

- Noble Gas Station
- Complementary Perspectives: Particulates (deposition, legacy fallout), Noble Gases (ongoing emissions)
- Seasonal Effects: Evident in both, stronger winter signals
- Primary Explanation: Anthropogenic emissions from civilian facilities
- Importance: Maintaining and enhancing IMS detection capabilitie
- Goal: Robust CTBT verification, environmental monitoring supports

Conclusion

- DEP33: Na-24 dominant, decreasing level≥3
- NOP49: Cs-137 & Co-60 at level 4
- SEP63: High Cs-137 frequency, diverse artificial nuclides
- RUP61: High I-131 occurrences, complex isotopic ratios
- All Concentrations: Remained below anomalous thresholds

Acknowledgments

The author sincerely thanks all colleagues and institutions for their valuable contributions of data, discussions, and technical support. Special recognition is given to the scientific community committed to strengthening the CTBT verification regime, advancing global environmental monitoring, and to the entire organization of SnT2025 for their dedication and excellence.