Measurement Strategies and Detection Limits for Particulate Filter Gamma-Ray Spectrometers in Real-Time Monitoring

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The surveillance and monitoring of airborne environmental radioactivity are critical for early detection of artificial isotopes. Gamma-ray spectrometers with particulate filters offer a combined solution for real-time and long-term monitoring that ranges from 10 minutes up to 5 days. We improve the capabilities of these spectrometers, developing measurement strategies and assessing Minimum Detectable Activity Concentration (MDAC) for the different time ranges.

The gamma-ray spectrometers use a scintillating crystal detector ($LaBr_3$(Ce) or SrI_2(Eu)) shielded by lead, with a glass fibre particulate filter inside the shielding. An air pump forces air through the filter to collect airborne particles. The monitors record spectra every 10 min and the filter is exchanged every 5 days, allowing the filter monitor to measure at different sensitivity and time resolution ranges simultaneously.

We propose 3 operational modes: **Real-Time Measurements** (isotope activity is measured every 10 minutes); **Measurement Since Last Filter Exchange** (Activity concentrations and MDAC vary depending on the time elapsed since the last filter exchange); and **Long-Term Averaging** (we estimate mean activity over extended periods, providing stable results and lower detection limits).

We show results for 2 different simulated situations:

1. A short, intense detection of ^{137}Cs by introducing contamination at specific times. The real-time method obtains detection limits in the range of 1 Bq/m³ for 10-minute measurements.

2. A Highly Diluted Cloud of ^{137}Cs to simulate a continuous low-intensity detection over several days. The detection limit varies significantly, improving as the filter ages. Averaging for 24 hours yielded more stable results, with detection limits reaching the mBq/m³ range towards the end of the filter cycle (MDAC values for ^{137}Cs reach 0.8 mBq/m^3 when using SrI_2(Eu) detectors over a 5-day integration period).

The study highlights the advantages of particulate filter monitors in achieving real-time measurements and better sensitivities over different timescales. The combination of measurement strategies allows for distinguishing between low average AC over long periods and high AC over short periods. Filter monitors provide a versatile solution for environmental radioactivity monitoring across various timescales, making them suitable for a wide range of applications, while relying on a single, multifunctional system capable of operating autonomously, unattended, and fully remote.