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Understanding radioxenon isotopical ratios originating from radiopharmaceutical facilities

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It was recently shown that radiopharmaceutical facilities (RPF) are major contributors to the general background of ^{133}Xe and other xenon isotopes both in the northern and southern hemisphere. To distinguish a nuclear explosion signal from releases from civil nuclear facilities, not only the activity concentrations but also the ratios of the four different CTBT relevant radioxenon isotopes (^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe) have to be well understood.

First measurements taken recently in and around two of the world's largest RPF's: NTP at Pelindaba, South Africa and IRE at Fleurus, Belgium have been presented. At both sites, also stack samples were taken in close cooperation with the facility operators.

The radioxenon in Belgium could be classified in four classes: the normal European background (^{133}Xe activity between 0 – 5 mBq/m^3) on one hand and then the samples where all four isotopes were detected with ^{133m}Xe/^{131m}Xe $<< 1$, ~ 1 or $>> 1$.

In northern South Africa the Pelindaba RPF is in practice the sole source of radioxenon. It generated a background of ^{133}Xe at the measurement site some 230 km to the west of the RPF of 0 – 5 mBq/m^3. In the cases where the air from the Pelindaba facility reached the measurement site directly and in a short time period, the ^{133}Xe was higher, also ^{135}Xe was present and in some samples ^{133m}Xe as well.

The ratios of the activity concentrations of ^{135}Xe/^{133}Xe vs. ^{133m}Xe/^{131m}Xe (Multiple Isotope Ratio Plot - MIRC) have been analysed. For both facilities, the possible theoretical ratio's for different scenarios were calculated with the information available and compared with the measurements.

It was found that there is an excess of ^{131m}Xe present in the European samples compared to theoretical calculations. A similar excess has also been seen in samples measured in northern America. In South Africa, neither the environmental samples nor the stack ones contained ^{131m}Xe at measurable levels. This can probably be explained by different processes and delay lines at the different RPF's.

From the measurements it can be concluded that probably special ^{131}I production lines emit more of the daughter nucleus ^{131m}Xe and push the ^{133m}Xe/^{131m}Xe ratios into the area of the MIRC plot that signifies reactor operation. Thereby it might mask a possible nuclear explosion signal.

A fresh RFP signal will in many cases be more similar to a nuclear explosion one in a ^{135}Xe/^{133}Xe vs. ^{133m}Xe/^{133}Xe plot, as the impact of a possibly anomalous emission history of ^{131m}Xe is here avoided. The thus reduced significance of the isotope ^{131m}Xe and its implication for monitoring the CTBT is discussed.

Disclaimer

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