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The 9th Workshop on Signatures of Man-Made Isotope Production

December 4-7th, 2023 in Santiago, Chile

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Overview of WOSMIP-IX

December 4-7th, 2023 Santiago, Chile

Introduction

The Ninth Workshop on Signatures of Man-Made Isotope Production (WOSMIP-IX) was held December 4-7th, 2023 in Santiago Chile, co-hosted by the Chilean Nuclear Energy Commission (CCHEN). The workshop had a total of 117 participants; 88 in-person and 29 virtual attendees. The detailed agenda and presentations for the workshop and the attendance list are located at https://www.wosmip.org/.

WOSMIP-IX consisted of the following main topical areas: measurement and understanding of radioxenon backgrounds, introduction to a list of potential sources of man-made radionuclides (aka, the "WOS-list"), emissions and sources of radionuclides, stack monitoring of facilities, Mo-99 production and atmospheric transport modeling (ATM) and events and measurements of interest. These topical areas consisted of presentations, a poster session, and a dedicated roundtable discussion around WOS-list, a new repository for xenon source term data. During the workshop, there was a tour of the RECH-1 Research Reactor, Nuclear Physics and Neutron Spectroscopy Center (CEFNEN), Cyclotron and National Environmental Monitoring Stations at the CCHEN. While at CCHEN, there was also a networking event that consisted of digital posters that covered topics such as: cytogenetic dosimetry (CCHEN), radionuclide dynamics in agriculture (CCHEN), international monitoring system stations for radionuclides (CCHEN/OTPCE), and source term analysis of Xenon (STAX) | (INVAP).

Measurements and Understanding of Backgrounds – Potential Issues/Problems Faced

One of the major themes and discussions at WOSMIP IX was how the impact of the backgrounds from anthropogenic sources has changed over time. This change was highlighted with the proximity of potentially impactful sources to International Monitoring System (IMS) stations. Two factors driving these changes were the increased demand for medical isotopes leading to more facilities of interest (including potentially hospitals if the location and release levels aligned) and new radioxenon systems with improved sensitivity that are being deployed throughout the IMS. With new radioxenon monitoring systems being available, the rate of installations in the IMS will need to increase to implement the new generation of systems throughout the IMS in a reasonable amount of time – before the first installations are obsolete. Systems such as the SAUNA Qb and Xenon International array could also prove to be beneficial for understanding varying background.

The analysis and categorization of signals observed at IMS stations was highlighted by multiple participants. With the new generation of systems, "Level C" samples will be more and more common, which highlights the need to better discriminate sources. It was also demonstrated that radioxenon systems can measure non-traditional (non-CTBT relevant) radioxenon isotopes (i.e., Xe-125, Xe-127, Xe-129m) from facilities that also include nuclear reactors. While these isotopes were previously only seen from sources like the Spallation Neutron Source (SNS), they were recently observed at the Hartlepool Nuclear Reactor, though only inside the facility. The use of stack monitoring data is already proving to be useful in identifying the source of radioxenon hits at stations. It was also shown that in cases where there isn't stack monitoring data, the historical releases (frequency and activity) can be used as a proxy

for estimating what the station might observe during a given period. Nigeria also highlighted their interest potentially hosting a background campaign and the benefit to the National Data Centers (NDC).

List of Potential Sources of Man-made Radionuclides WOS-list

To better understand the backgrounds and the impact on the IMS, the WOS-list was started to make sure the community was using a single repository of information when evaluating the different sources. The WOS-list identifies the name, location, and other meta data for the source that may be used in the analysis of IMS station data. While the repository is currently focusing on identifying reactors and medical isotope production facilities, the community agreed that having an agreed-on list and agreed-on locations would be a good first start. The community also identified other meta data such as stack height, reactor type, and maximum release activity that could be included. Additionally, other types of sources like the SNS, hospitals, and research reactors are of interest to the community.

Emissions and Sources of Radionuclides

The importance of the WOS-list and additional information was highlighted when discussing other radioxenon emissions. Molten Salt Reactors (MSRs) were highlighted as a potential large source of radioxenon isotopes in the future, with the potential for releases of 10^{16} Bq/Day for a 100-MW MSR. Implementing abatement technologies for these new types of reactors needs strong emphasis. The work that has been implemented in medical isotope production facilities may be able to aid in reducing the emissions at these new reactors. While the emissions from a MSR have the potential to be extremely high, the emissions for Hartlepool reactor were studied and found to be about an order of magnitude lower than previously expected. This variation in release levels shows the potential impact of reactor design and highlights the need to understand the global emissions sources.

This session was closed out with discussion on zeolites and better understanding the long-term degradation of abatement technologies. The use of the zeolites in the abatement of radioxenon from medical isotope production facilities is seen as a win for WOSMIP as the technologies were first discussed at early WOSMIPs and are now in operation.

Stack Monitoring of Facilities

During a visit to the CCHEN facility, participants had a discussion on the benefit of additional measurement systems to identify the source locations. In addition to the site visit, there were extensive discussions around the topics presented in the poster sessions. Posters covered topics including background campaigns, isotope production, stack monitoring, field experiments, laboratory operations, atmospheric transport modeling (ATM) studies, and many more.

The STAX project was highlighted as it is now in multiple facilities and the data is actively being used by NDCs. The data is readily available, and the software makes it very easy to utilize the data in additional analysis. Presentations were given to demo the software used to obtain the data and how to interact with the STAX data. While there are many uses for the STAX data that are being identified, it was highlighted that it will be important to understand how to compare NDC results if one NDC is using the STAX data and another isn't. Participants were reminded that access to the STAX data is only possible via explicit permission given by the facility supplying the data.

Production of Mo-99

The National Nuclear Security Administration (NNSA) and medical isotope producers discussed the status of new facilities that are being built in the United States along with other operating facilities around the world. A major accomplishment was that all the major producers around the world are now operating with Low Enriched Uranium (LEU) targets. NNSA is working with the new U.S. facilities to both implement a STAX detector and reduce emissions through abatement technologies. Current Mo-99 providers detailed their efforts to both ramp up production, but also minimize radioxenon emissions through gas hold up and abatement techniques.

Atmospheric Transport Modeling & Events of Interest

During the discussions of atmospheric transport models, different models were detailed along with the use of additional sensors (SAUNA Qb array) to provide more input data to aid in the event analysis and source identification. The ATM discussions highlighted the uncertainty of the models and how to use the data to confirm the sources of radioxenon. Additionally, the impact of local terrain at either the source or receptor were highlighted when comparing against regional models. Example of these terrain impacts were seen with where the plume is released, but also if a station is at elevation such as the DEX33 IMS station on Mount Schauinsland, outside of Freiburg, Germany.

The frequency of radioxenon detections was also investigated and compared to the expected results from ATM. While the production of Mo-99 has gone up about 3-5% annually, the overall xenon emissions seem to be going down. This could be that the emissions are lower or that with Chalk River closing, there are fewer large activity hits. Understanding if it is the total emission or detection frequency that is changing will be of interest with new systems coming online. The thresholds when these signals are seen as a high-level event need to be studied to better identify signals that would be expected from a nuclear explosion compared to anthropogenic sources.

During studies in Sweden, the use of the SAUNA Qb array demonstrated how the location of the plume can be better localized when more stations are available at a smaller spacing.

Recommendations and Observations

Experts at WOSMIP had a few recommendations for further work in this area including:

1) The monitoring community agreed that the efforts to create and maintain a list of potential sources of airborne radioactivity continues to be an important task for WOSMIP. Current fields and additional fields were discussed, including emission location, emission type, expected hits and many more.

2) Participants were enthusiastic about the use of STAX data and agreed that continued use within the analysis and leveraging by NDCs will help to better understand how the data can be leveraged by the community.

3) Participants were very grateful for the efforts by the medical isotope producers to reduce emissions and provide stack monitoring data. It was agreed that continued collaboration will be important to the success of the background minimization efforts for the monitoring community.

4) Participants highlighted the importance potential sources of “non-traditional” radioxenon isotopes throughout the workshop. The usual sources of radioactivity include new types of nuclear reactors and medical isotope production facilities, hospitals, and spallation neutron sources. These other sources should continue to be studied and should also be added to future iterations of the WOS-list.

Conclusions

Two awards were given at WOSMIP-IX (WOSTER/WOZZIE), the WOSTER for best poster and the WOZZIE for overall contribution to the community. The WOSTER was awarded to Sri Sundari Retnoasih of the National Research and Innovation Agency (BRIN) of the Republic of Indonesia for “Estimation of Radioxenon Release Trajectory Plots Based on the Recent Development of the Molten Salt Reactor.” The WOZZIE award went to Dr. Andrew Petts of EDF Energy of the United Kingdom for his pioneering work to understand emissions from nuclear reactors.

The partnership between CCHEN and PNNL is a major accomplishment in the field of nuclear explosion monitoring and showcases the dedication of both organizations to advancing this critical effort. The STAX project and WOSMIP represent significant steps towards a safer and more secure world.