Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire
Canada

An Overview of Tritium Analysis at the CNSC Laboratory

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Canada

Outline

- Canadian Nuclear Safety Commission (CNSC)
- CNSC Laboratory Activities
- Tritium Analysis in our Laboratory
- Summary

Canadian Nuclear Safety Commission

- CNSC was established under the *Nuclear Safety and Control Act*, celebrating over 75 years of nuclear safety

- **CNSC Mission:** Regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment, implement Canada's international commitments on the peaceful use of nuclear energy, and disseminate objective scientific, technical and regulatory information to the public
- **Laboratory Mission:** The CNSC laboratory provides testing and calibration services, to support regulatory compliance, environmental monitoring, safeguards and nuclear forensic activities
  - Calibration Laboratory: ISO 17025 accredited for calibration of gamma survey and contamination meters
  - Testing Laboratory: Initial assessment for ISO 17025 accreditation of testing methods in water and swipe samples in June 2023

Testing Services: Inorganic Chemistry

Sample Matrix	Analytes	Method
Water	pH	pH Electrode
Water	Ammonia (NH_3)	Ion Selective Electrode
Water	F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}	Ion Chromatography
Water	Total Dissolved Solids (TDS) and Total Suspended Solids (TSS)	Gravimetric Determination
Water	Total Organic Carbon (TOC)/Inorganic Carbon (IC)	Total Organic Carbon Analyzer
Water	Hydrazine/morpholine	HPLC
Water	Trace elements	ICP-MS
Soil, Sediment, Vegetation, Food	Trace elements	Digestion + ICP-MS
Air (particulate)	U, Be	Digestion + ICP-MS

Testing Services: Radiochemistry

Sample Matrix	Analytes	Method
Air (Particulate), Air (Iodine), Water, Food, Vegetation (Grass), Soil/ Sediment, artefact	Gamma Emitting Radionuclides (e.g., Co-60, Cs-137, I-131, etc.)	Gamma Spectrometry
Air	HTO and HT	Liquid Scintillation Counter
Water	Ra-226	Alpha Spectrometry
Water	Gross Alpha and Gross Beta	Gas Proportional Counter
Water, Vegetation (Grass), Food	HTO	Liquid Scintillation Counter
Food	HTO and OBT	Liquid Scintillation Counter
Swipes	Gross Gamma	Well-Type NaI Gamma Counter
Swipes	Gross Alpha and Gross Beta	Liquid Scintillation Counter

Environmental Monitoring

International Atomic Energy Agency states that "…the regulatory body shall be responsible, as appropriate for… making provisions for an independent environmental monitoring program"

Objective: To **independently verify** that the public and the environment around nuclear facilities are protected

Interest from Commission members, Indigenous groups, and members of the public

To **complement** CNSC's ongoing environmental protection compliance verification activities

The independent environmental monitoring program (IEMP) is independent of the licensees' Environmental Monitoring Programs (EMPs) and doesn't relieve them of their responsibilities

Regulatory Oversight

CNSC licensees monitor tritium in air, water, vegetation, and food samples as part of their environmental monitoring programs

CNSC staff ensure that the licensee complies with CNSC regulations through desktop reviews and inspections

The predominant chemical forms of tritium measured include HT and HTO in air and HTO in water

CNSC staff also independently measure tritium concentrations in environmental samples taken near licensees through compliance inspections, environmental monitoring campaigns, and research studies

Organically bound tritium (OBT) is often estimated from HTO measurements based on a mean OBT/HTO ratio of 0.7

CNSC Laboratory: OBT Workshop/Intercomparison Exercises

A member since 2012

First exercise: fish, potatoes, and Swiss chard

Second: sediment

Third: wheat

Fourth: grass

Fifth: fish

Sixth: quince

Sample Preparation: Freeze-drying

- Fresh sample is cut into small cubes or chopped into 1cm pieces and stored in the freezer prior to drying
- Freeze-drying under vacuum is used to obtain tissue free water and dry the fresh samples
- During freeze drying, the sample is super cooled with liquid nitrogen
- The sample is then gently heated, the tissue-free water vapour is vacuum drawn, and collected in the super cooled collection flask
- This results into two sample portions: tissue-free water portion and a dried sample

Custom-built lab freeze-drying setup

Sample Preparation: Drying and Grinding

- Freeze-drying typically dries the sample up to 98%, therefore, the dried sample from freeze-drying step is further oven dried at 55°C
- Alternatively, in the absence of freeze-dryer, the entire fresh sample can be dried in the oven at 55°C
- The dried sample is then ground into a fine powder and pressed into a pellet before combustion to ensure a uniform and complete combustion

Grinder/mill

Press

Sample Preparation: Making Pellets

Dried food sample from the freeze-drying step is retrieved and further died in the oven

↓

The oven dried sample is milled/crushed and made into a compressed pellet

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Sample is combusted to collect OBT water

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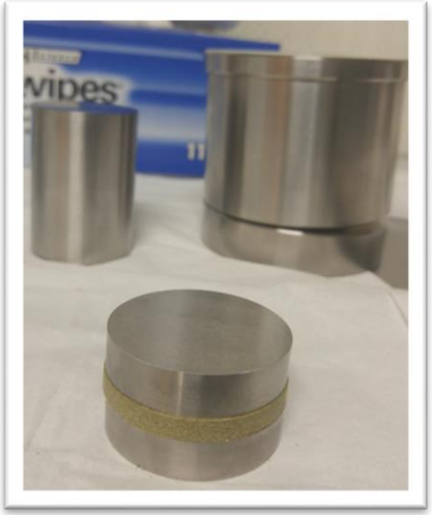
OBT water is purified

↓

OBT water Sample is measured by LSC

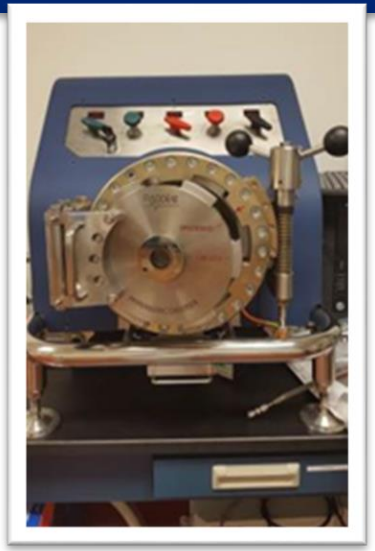


Die

Pelleted grass sample

Combustion Method: Samples with High Organic Content

- Two Parr oxygen chambers
- Two hyperbaric HBO2 oxidizers



RADDEC Hyperbaric Oxidizer (Sample mass up to 20g)

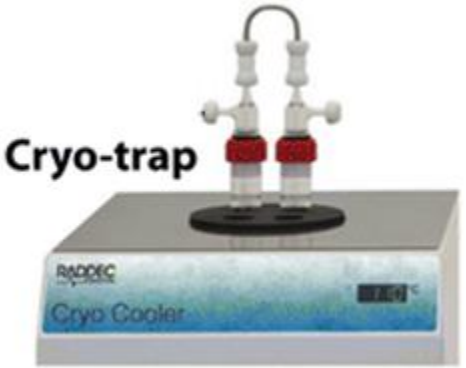
Parr Oxygen Chamber (Sample mass up to 10g)

Sample Combustion Using Parr and HBO2 Oxidizer

- Once the pellet is prepared, the pellet is placed into the combustion cup
- Both are pressurized oxygen chambers equipped with an ignition system
- A low voltage current is applied to the fuse wires to ignite the fuse wire in contact with the sample
- The highly combustible sample, such as food is then fully oxidized to water and carbon dioxide
- The water as the combustion product is collected

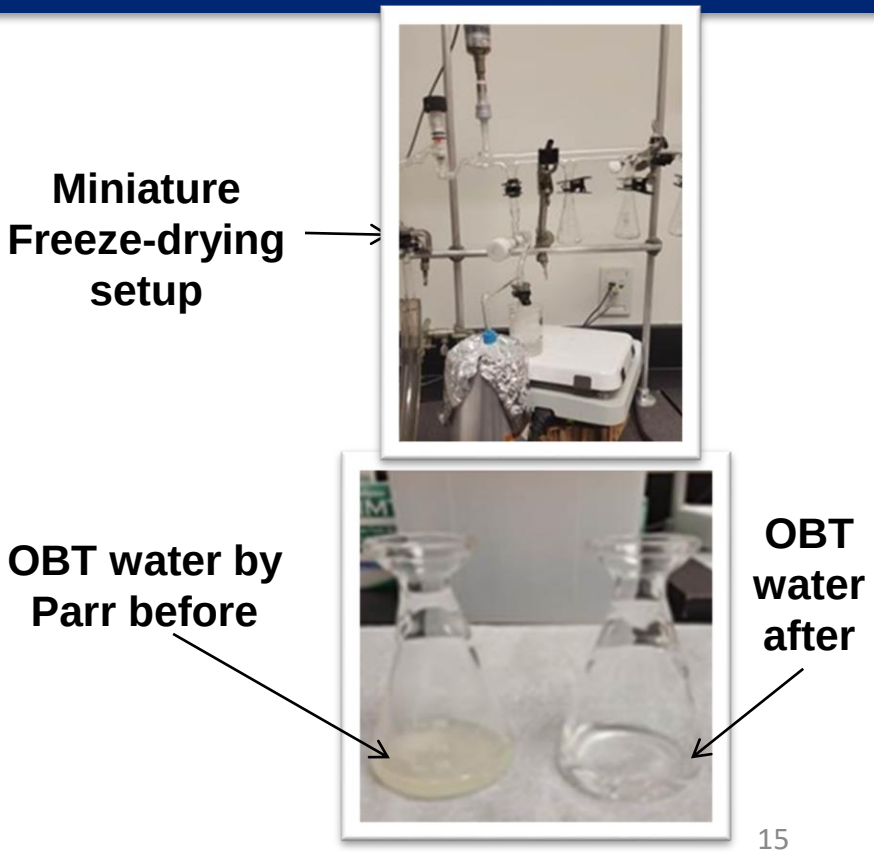
OBT Water Collection

- For biota, meat, and vegetation, the dried sample is combusted using a RADDEC oxidizer or Parr chambers
- Using the RADDEC oxidizer, the OBT water is collected in cryo-cooler traps and chemically treated, if needed, followed by freeze-drying
- Using the Parr, the OBT water is further chemically treated, if needed, in a miniaturized freeze-drying set-up
- The OBT water is counted on a low-background LSC (Quantulus GCT)



OBT Water: Freeze-drying

- Recovered OBT combustion water is collected and purified by freeze-drying setup up to two times
- In case of meat, fish, and milk samples, the OBT water is chemically treated prior to freeze-drying



Combustion Method: Samples with Low Organic Content

- One Pyrolyser with 4 tubes
- One home-made double tube furnace
- Both have sample and catalyst heating zones

RADDEC Pyrolyser (Pt-Alumina as catalyst)

Double tube furnace (copper turnings as catalyst)

Licensed Facilities

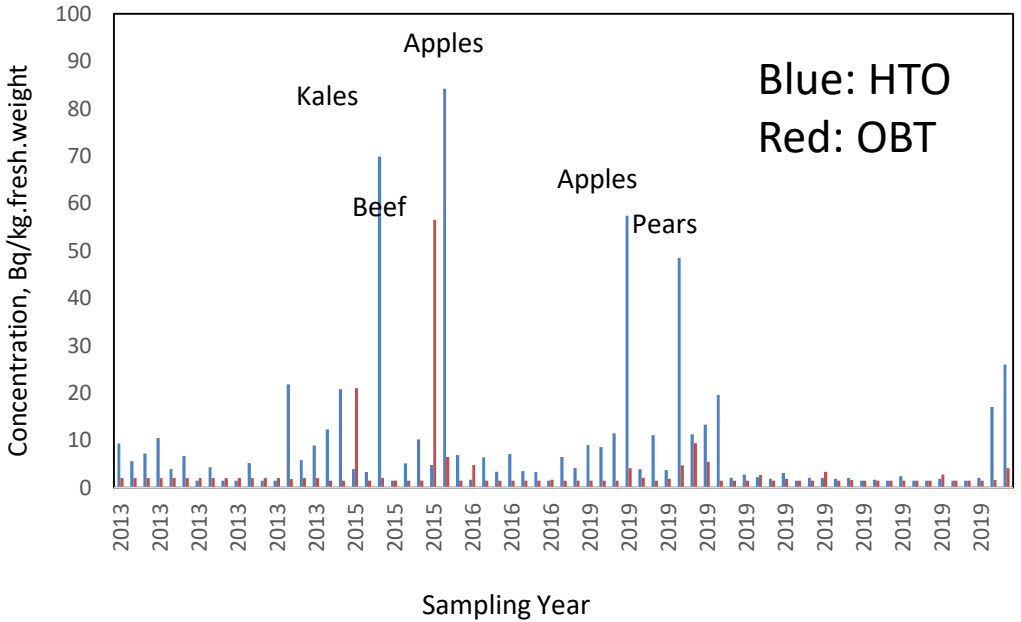
- Nuclear power generating stations
- Radioactive waste management facilities
- Tritium processing facilities, SRBT
- Tritium removal facilities
- Research facilities
- Chemical laboratories
- **CNSC's IEMP sampling locations around Licensee sites**

Sampling Sites
Across Canada

Tritium Concentrations (HTO and OBT) in Locally Grown Food Near NPP

Sample Type	Guideline/ Screening Level*: HTO (Bq/Kg fresh weight)	Guideline/ Screening Level*: OBT (Bq/Kg fresh weight)
Leafy Vegetable	104,000	45,200
Apples	123,000	50,300
Meat	159,000	69,300
Fish	488,000	212,000

*CSA N288.1



Tritium Concentrations in Food Near Tritium Processing Facility

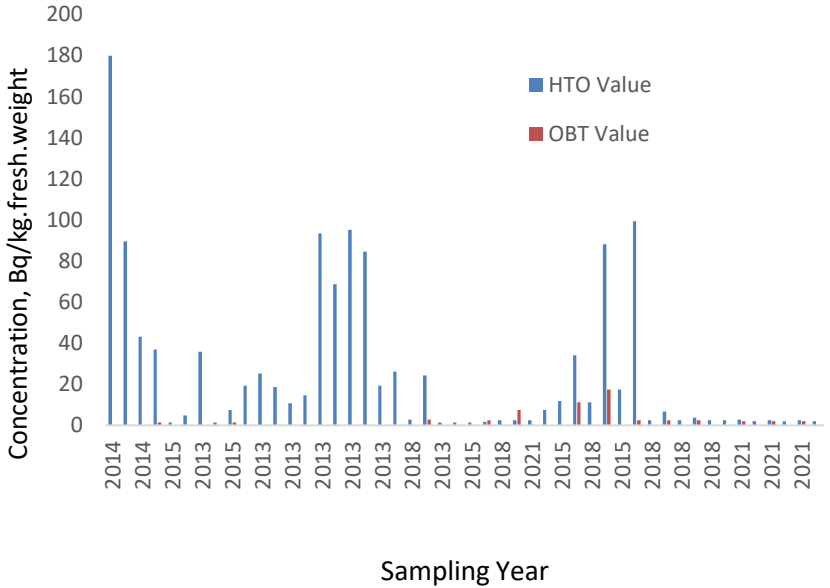
- Tritium processing facility: Tritium (HTO and HT) emissions in air are sampled using bubbler sampler

- Products containing gaseous tritium light sources

Exit Signs

Aircraft Signs

Safety Markers



SRBT Tritium Processing Facility

Distance	Tritium concentration in air Bq/m^3 (annual average)	Range (Bq/m^3)
62 m	35.66	1.6–139.0
220 m	19.05	3.9–56.4
1050 m	3.42	1.3–7.2

Watering regime	Material		OBT / HTO ratio	HTO activity (Bq/L)	OBT activity (Bq/L)
rain water (80 Bq/L)	plant	stems/leaves	**10.5**	86	741
	soil		0.8	101	108
tap water (5 Bq/L)	plant	stems/leaves	**11.3**	98	1009
	soil		1.1	103	90

Summary

Radionuclide concentration levels in all samples are either less than or close to the respective minimum detectable concentrations, except for tritium where low activity values above the minimum detectable concentration were measured

Tritium concentration levels are comparable to the background levels and are within the ranges of other reported environmental radiological monitoring programs in Canada

Concentration levels in food samples are well below the intervention level for radioactivity in foodstuff

Doses from water, air and foodstuffs are well below the guideline limits and radiation background values

The dose contribution from tritium typically represent a small fraction of public dose limit in Canada

Members of the public living around the Canadian NPPs are not exposed to levels of radiation that would result in a radiological health impact

Questions?

Thank You!