SNC·LAVALIN

Landfill Disposal and Thermal Treatment Considerations for Solid Waste Containing PFAS

Matt Pourabadehei, Ph.D., P.Eng.

June 3rd, 2021

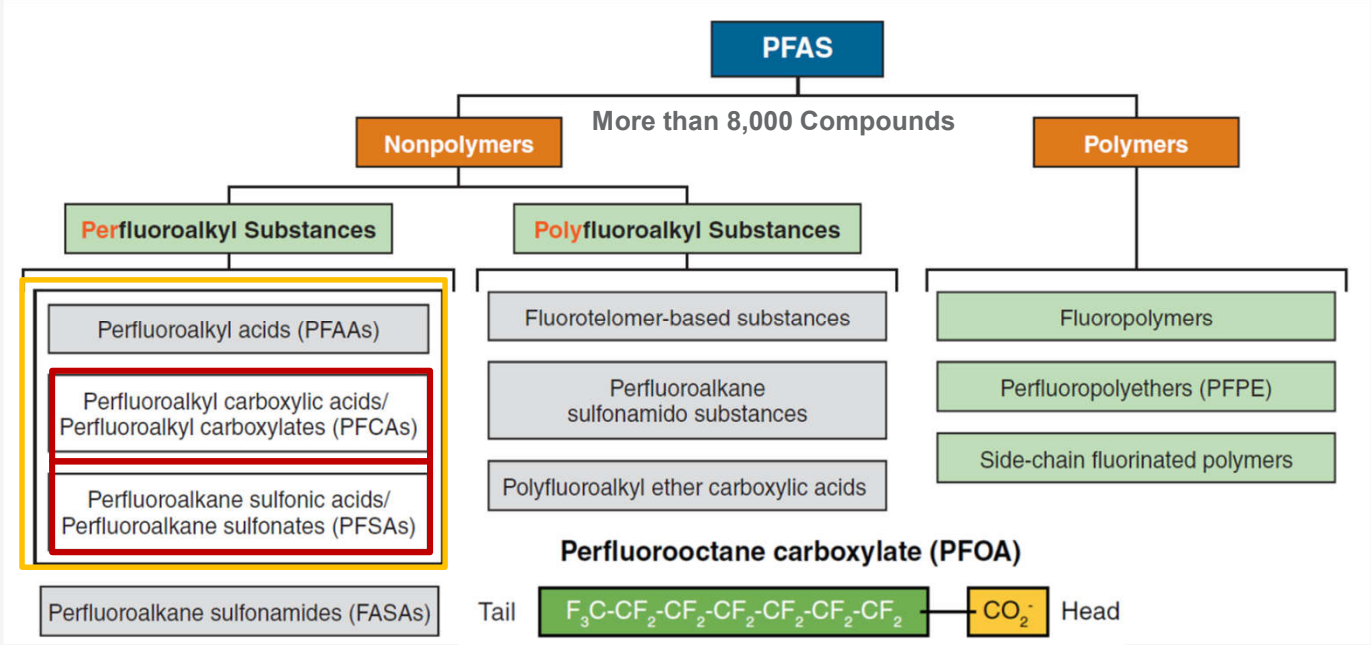
Disclaimer

This presentation provides a summary of selected scientific studies and management plans with respect to the offsite disposal of solid wastes containing PFAS.

The intention is not to establish criteria or standards for landfill disposal of wastes containing PFAS. As such, the following constitutes general technical information based on industry-available knowledge and current understanding of this emerging contaminant.

What Are PFAS?

ITRC 2018, Naming Conventions and Physical &Chemical Properties of PFAS.



SNC·LAVALIN

Virtual EnviroTech 2021

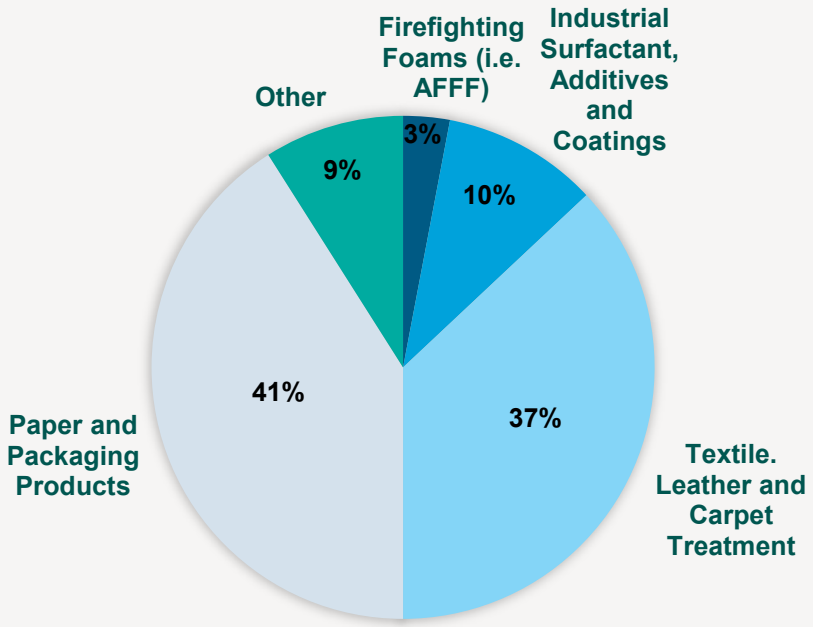
Why They Are Important?

Unique Physical and Chemical Properties (have been used in many products):

› Oil and Water Repellence (application: coatings for textile, paper, surface and cookware);

› Thermal Stability and Temperature Resistance (application: thermal resistant plastic, AFFF); and

› Friction Reduction (application: hydraulic fluid).



PFOS Production in 2000 by 3M
(Schultz et al., 2003)

SNC·LAVALIN

Virtual EnviroTech 2021

Background

Environmental investigations at contaminated sites generally result in excess solid and/or liquid wastes to be managed, or remedial soil removal. This is often referred to as Investigation/Remediation Derived Waste (IRDW)

Solid IRDW:
Soil, GAC Filter, IX Resin Filter, etc.

Liquid IRDW:
Purged Groundwater, Excess Equipment/Rinsate Blanks, Hydrovac Water and Excavation Dewatering.

Landfill Disposal - A Feasible Option for IRDW Containing PFAS?

There are few options available to manage IRDW Containing PFAS:

- Destructive Approaches: e.g. Thermal Treatment (normally a cost prohibitive approach, but effective to reduce/eliminate PFAS in residual solids)
- Non-destructive Approaches: e.g. Immobilization and Containment Techniques (more cost-effective when compared to destructive methods)

On-Site Encapsulation

Engineered Facility: mainly for large volumes of impacted soil

Stabilization and/or Solidification

In Situ or *Ex Situ*

Off-Site Disposal

Transporting to an approved receiving facility (operated by 3rd party)

Off-Site Disposal (Non-Hazardous Landfills)

Why Do Waste Generators Select This Approach?

- PFAS have not been categorized as Hazardous Materials in Canada, yet!
- Absence of environmental regulatory framework, federally and provincially, for managing IRDW containing PFAS (less restrictive; however, liability is not well defined);
- Can be a cost-effective method for managing small and large volumes of solid IRDW (dependent on PFAS concentrations and leachability);
- Accepted by waste hauler and waste receiver (lack of knowledge about the fate and transformation of PFAS in IRDW waste and environmental consequences);

What happens when solid wastes containing PFAS are disposed in landfills?

PFAS Fate and Transformation in Canadian Landfills
(Municipal and Commercial Landfills)

- A variety of consumer products containing PFAAs and their precursors are sent to municipal landfills at the end of their useful lives.

Following disposal, PFAS are released from the waste through biological and abiotic leaching.

- PFAAs are routinely detected in landfill leachate, with short chain (C4-C7) PFAAs being most abundant:

Leachate from certain lined landfills are collected and sent to WWTPs → not equipped to remove PFAS.

Raw Landfill Leachate from Operating landfills (Mixed Wastes, btw Feb. & June 2010), mean conc. (ng/L):

PFOA= 210, PFOS=80, PFBA=70, PFBS=28

(Benskin et al., 2012 & Hamid et al., 2018)

SNC·LAVALIN

Virtual EnviroTech 2021

PFAS Fate and Transformation in Canadian Landfills

- Presence of PFAA-precursors in landfill leachates (from mixed wastes) at concentrations comparable to, or higher than, the most frequently detected PFAAs:

PFAA precursors: fluorotelomer-based (e.g., n:2 FTCA, FTUCAs) and N-alkyl FASAAs

The extent of transformation measured (site-specific), ranging between 10% and 250% for individual PFAA.

- Landfill ambient air containing elevated concentrations of semi-volatile precursors (e.g., fluorotelomer alcohols) compared to upwind control sites;

Landfill gas condensate was reported to contain C4-C8 PFAAs, with PFBS being the dominant compound at a concentration of 1,000 ng/L (Li, 2011)

(Benskin et al., 2012 & Hamid et al., 2018)

PFAS in Landfill Leachates in Other Countries (mixed wastes)

USA:

- PFSA concentrations in landfill leachate have varied from 50 to 3,200 ng/L in the USA, with median concentrations of a few hundred ng/L for C4-C8.
- PFCA concentrations in landfill leachate have varied from 10 to 8,900 ng/L (contributed 20%-90% of ∑PFAS), mainly C4-C6.

Australia

- The maximum concentrations of PFSA and PFCA (C4-C8) in landfill leachate were 1,900 ng/L and 5,700 ng/L, respectively,
- In general, the concentrations of C4-C8 PFAS in landfill leachate samples were lower than in samples collected in the USA.

Gallen et al. (2016; 2017), Allred et al., 2014; Huset et al., 2011

Leachate Treatment System[1]

Survey of 10 landfills (active and closed, with municipal and/or commercial wastes) in Australia, Spain, Germany, Finland, the USA and Canada shows that the leachate treatment systems located in the waste facilities generally consist of:

- Biological (e.g. aerobic pond) & physical filtration.
- Off-site at WWTP; or
- Evaporation pond & off-site at WWTP;
- On-Site WWTP

Not Effective to Treat PFAS in the Leachate, Bio-transfer PFAA precursors to the terminal PFAA compounds (e.g. PFOA, PFOS)

[1] H. Hamid et al., 2018 (Envir. Pollution)

Landfill Disposal Considerations[1] (IRDW Containing PFAS)

According to the Australian "*PFAS National Environmental Management Plan*", waste facilities are NOT recommended to receive IRDW containing PFAS if:

I. The landfill is located on a vulnerable aquifer;

II. The landfill is located within 1.0 km of a surface water body (or connected to groundwater and/or discharges directly into an aquatic environment), or any sources of current or future drinking water well;

III. The landfill liner's integrity is not intact and/or has a poor leachate management system;

IV. The landfill has no wastewater treatment plan or a poorly designed treatment plan; or

V. The landfill has no progressive capping system or a poorly designed system.

[1] PFAS National Environmental Management Plan,
The Heads of EPAs Australia and New Zealand (HEPA), Jan. 2018.

Challenges for Identifying Appropriate Landfills Receiving General IRDW Containing PFAS

- Auditing existing landfills would be costly and time-consuming;
- In the absence of federal/provincial guidelines/standards, PFAS are not being monitored in leachates.
- Landfills/WWTPs in Canada are generally not equipped to remove PFAS from leachates; and

Technical Suggestion

Minimum criteria for landfills to qualify receiving a wide range of IRDW containing PFAS 

Sufficiently characterize the wastes → Select an appropriate landfill based on the waste characters and potential risk estimation

SNC·LAVALIN

Virtual EnviroTech 2021

How to Characterize the IRDW Containing PFAS

- IRDW should be sufficiently characterized by the waste generator/owner
  a) By collecting composite sample(s) and analyzing for PFAS; and
  b) Conducting Leachability Test to estimate potential risk (PFAS release from IRDW).

Leachability Testing[1]
- Leaching Environmental Assessment Framework (LEAF):
  - EPA -1313
  - EPA -1314
  - EPA -1315
  - EPA -1316
- Synthetic Precipitation Leaching Procedure (SPLP) – EPA 1312
- Toxicity Characteristic Leaching Procedure (TCLP) – EPA 1311

[1] Leaching Environmental Assessment Framework (LEAF) How-To Guide. SW-846 Update VI. Oct. 2017.

SNC·LAVALIN

Virtual EnviroTech 2021

US EPA – Addendum to the Waste Classification Guideline (2014)

TCLP and Specific Contaminant Concentration (SCC) for Classifying Waste by Chemical Assessment

(Maximum Values for Leachable Concentration and SCC When Used Together)

Contaminant		PFOS + PFHxS	PFOA
General Solid Waste	Leachable Concentration (TCLP*)	50 µg/L	500 µg/L
	Specific Contaminant Concentration (SCC)	1.8 mg/kg	18 mg/kg
Restricted Solid Waste	Leachable Concentration (TCLP*)	200 µg/L	2,000 µg/L
	Specific Contaminant Concentration (SCC)	7.2 mg/kg	72 mg/kg

*TCLP: Toxicity Characteristic Leaching Procedure

SNC·LAVALIN

Virtual EnviroTech 2021

Australia and New Zealand Landfill Acceptance Criteria (2018)

Landfill acceptance criteria for total concentrations in soil is capped at **50 mg/kg**

(in accordance with PFOS requirement of the Basel Convention)

Landfill Type		PFOS / PFHxS	PFOA	Comments
Unlined	ASLP* Leachable Concentration	0.07 µg/L	0.56 µg/L	Australian Drinking Water Guideline **x1**
	Total Concentration	20 mg/kg	50 mg/kg	Soil – Human Health (Ind/Com) **x1**
Clay/Single Composite Lined	ASLP* Leachable Concentration	0.7 µg/L	5.6 µg/L	Australian Drinking Water Guideline **x10**
	Total Concentration	50 mg/kg	50 mg/kg	Soil – Human Health (Ind/Com) **x10****
Double Composite Lined	ASLP* Leachable Concentration	7 µg/L	56 µg/L	Australian Drinking Water Guideline **x100**
	Total Concentration	50 mg/kg	50 mg/kg	Soil – Human Health (Ind/Com) **x100****

*ASLP: Australian Standard Leaching Procedure

**up to maximum 50 mg/kg

SNC·LAVALIN

Virtual EnviroTech 2021

Possible Similar Approach for Canada: Canadian Health-Based Regulations

(HC DWG/DWSV & HC SSV, May 2019)

In accordance with the Basel Convention total concentration of PFOS in soil could be capped at **50 mg/kg**

Landfill Type		PFOS / PFHxS	PFOA	Comments
Unlined	LEAF* Leachable Concentration	0.6 µg/L	0.2 µg/L	Health Canada DWG/DWSV **x1**
	Total Concentration	30.2 mg/kg	9.94 mg/kg	Soil – HC SSV (Ind/Com) **x1**
Clay/Single Composite Lined	LEAF* Leachable Concentration	6 µg/L	2.0 µg/L	Health Canada DWG/DWSV **x10**
	Total Concentration (mg/kg)	50 mg/kg	50 mg/kg	Soil – HC SSV (Ind/Com) **x10****
Double Composite Lined	LEAF* Leachable Concentration	60 µg/L	20 µg/L	Health Canada DWG/DWSV **x100**
	Total Concentration (mg/kg)	50 mg/kg	50 mg/kg	Soil – HC SSV (Ind/Com) **x100****

* LEAF: Leaching Environmental Assessment Framework

**up to maximum 50 mg/kg

SNC·LAVALIN

Virtual EnviroTech 2021

Conclusions

PFAS has been detected in raw and treated landfill leachates in Canada.

In the absence of federal/provincial guidelines/standards, wastes containing PFAS have been and will continue to be transported to non-hazardous landfills.

Sending such wastes to non-hazardous landfills may NOT be the best waste management practice, when the wastes are not sufficiently characterized by the waste generators/owners to reflect the nature of the waste and the associated risk (i.e. potential leaching or vapour discharge of PFAS) to the waste receivers.

Other jurisdictions have restricted disposal of material with PFOA or PFOS+PFHxS to concentrations less than 50 mg/kg in the municipal/commercial landfills.

If leachates are not monitored for PFAS, landfills have the potential to become a source of PFAS contamination for offsite soil, sediment, water, air and biological compartments.

Thank you for listening

Question & Answer Time!

SAFETY

INTEGRITY

COLLABORATION

INNOVATION

SNC·LAVALIN

Virtual EnviroTech 2021