NSWBI Technical Webinar #2

Dumps, Landfills, Emerging Contaminants and Impacts on Landfill Leachate Quality due to Increased Organics Diversion:

What do we expect and what do we know?

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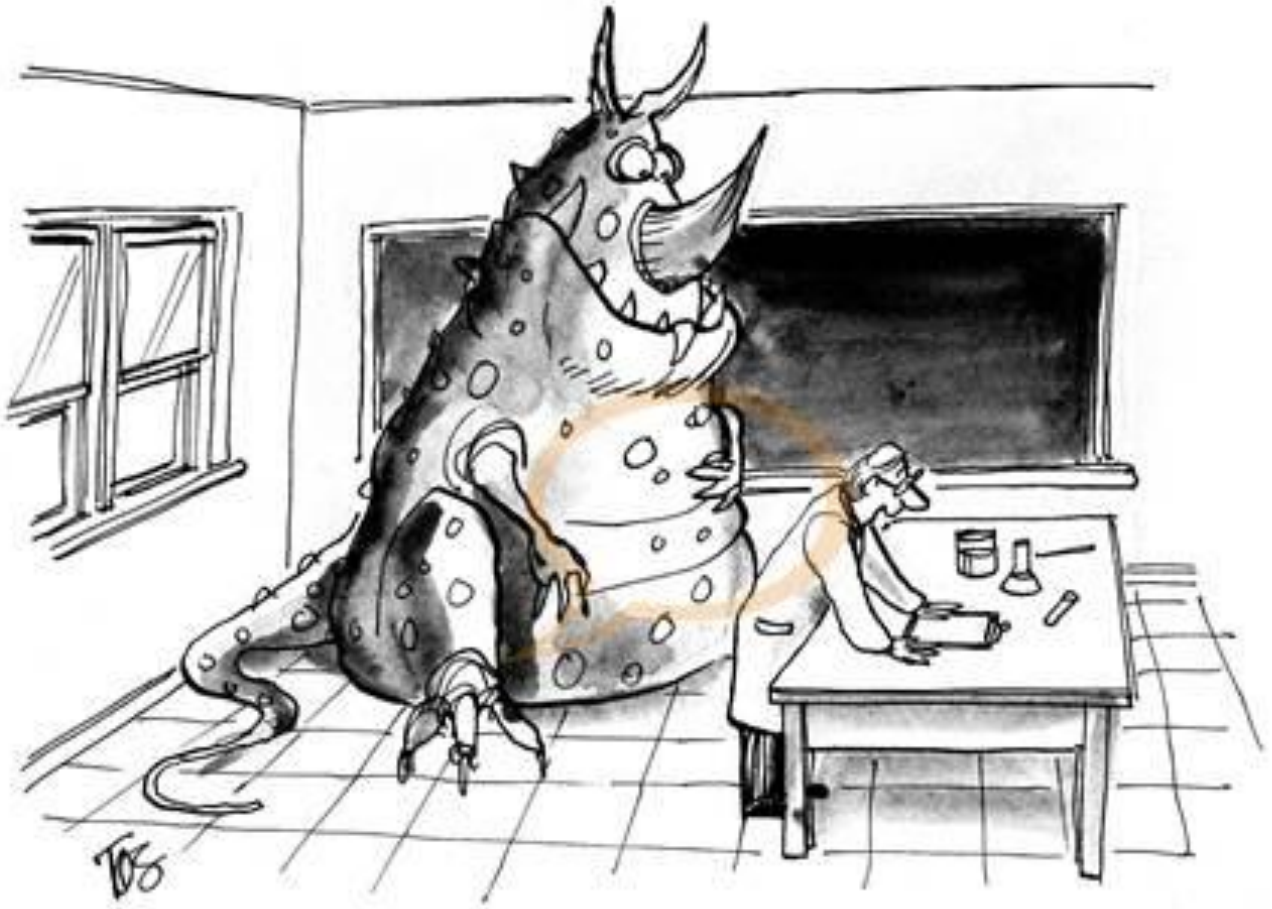
Dumps/Landfills End of Life (EOL) Management



"Son of a gun, you're right, there were some harmful compounds in those chemicals we dumped."

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Today's Discussion

- Background on Landfill Leachate Generation and Characteristics
- Leachate Treatment
- Leachate Quality and Increased Organics Diversion
- Case Studies
- Emerging Contaminants in Landfills
- Unique Challenges with Northern dumpsites/landfills
- What Comes Next?

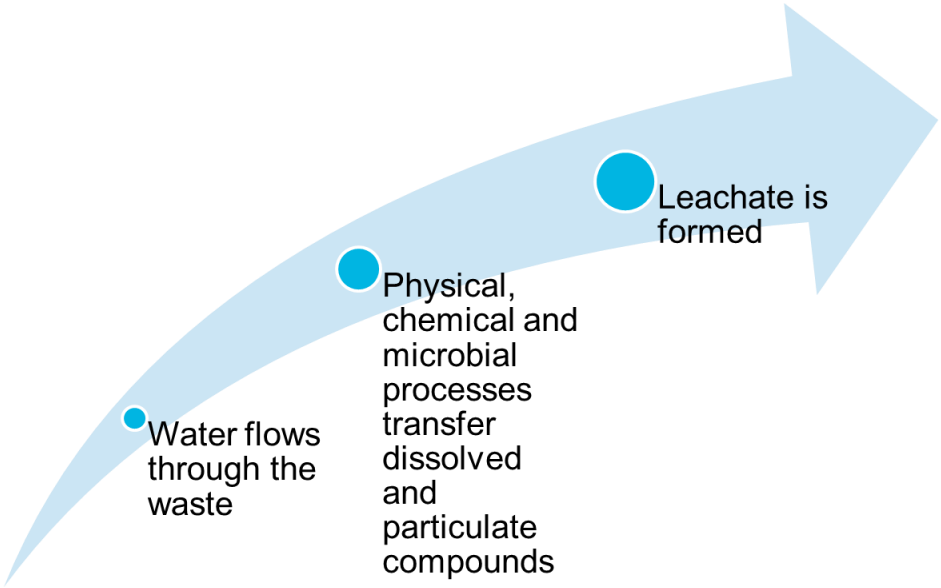
Background on Landfill Leachate Generation and Characteristics

What is Leachate?

– Formed when water *percolates* through a substance and acquires soluble materials from that substance
  - Ex. Water through coffee grounds

– Waste *composition* affects composition of leachate

– Dark brown/black, strong odour



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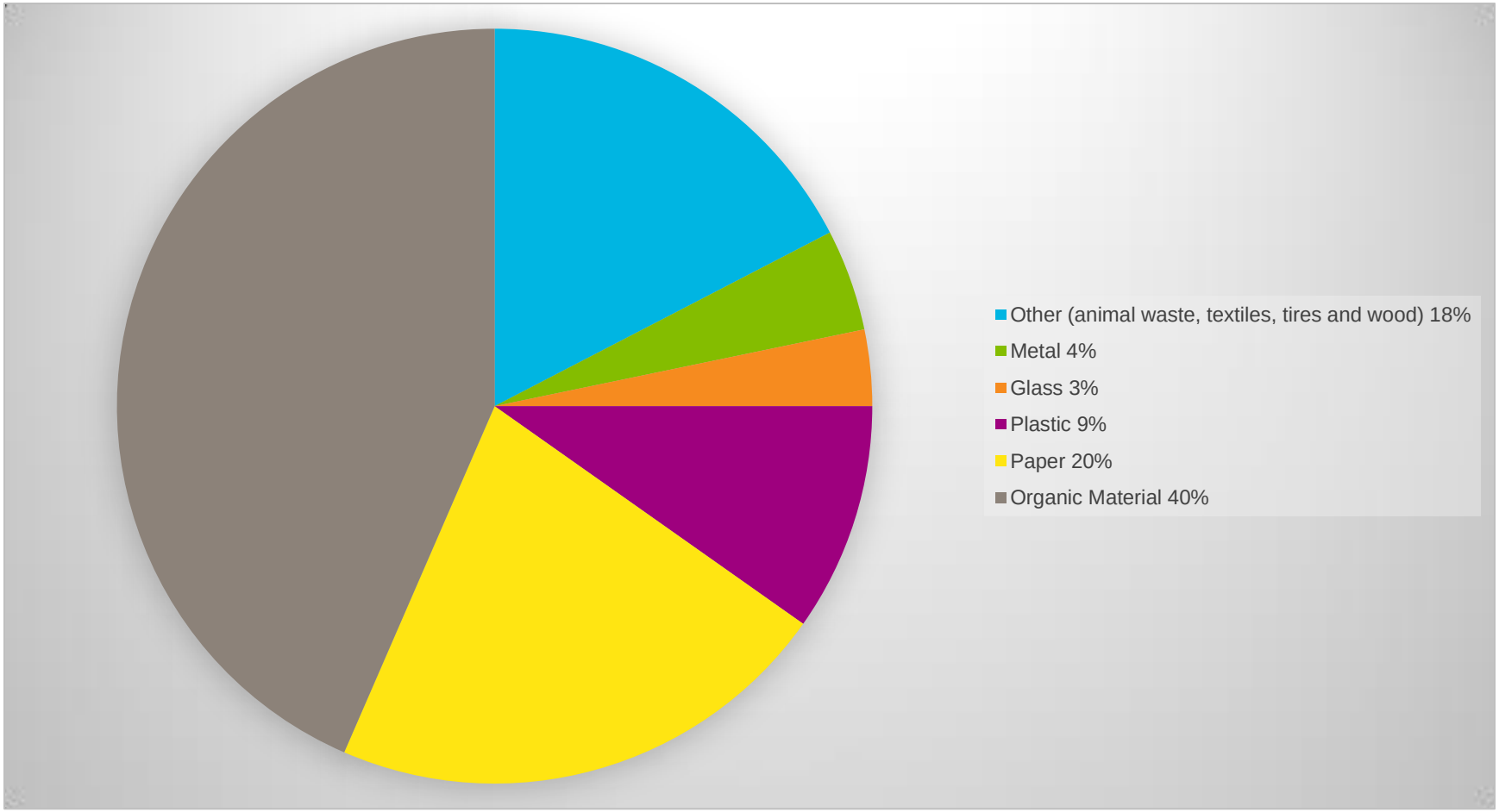
Composition of Waste in Canada



Statistics Canada 2005

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Four Main Contaminant Groups

Dissolved organic matter

- Alcohols, acids, aldehydes, short chain sugars, and more stable organics

Inorganic macrocomponents

- Cations and ions including: calcium, magnesium, manganese, sodium, potassium, chloride, sulphate, iron, ammonia, and carbonates

Metals

- Dissolved metals including: lead and mercury

Organic compounds

- Aromatic hydrocarbons, phenols, halogenated organics (i.e. PCBs, PBDEs, PFCs, dioxins), pesticides, solvents, and plasticizers

Four Parameters for Characterization

pH

- indicates level of acidity of the liquid

Specific conductance

- ability to conduct electricity

Chemical Oxygen Demand (COD)

- indicator of total amount of organic matter in leachate

Biochemical Oxygen Demand (BOD)

- measure of amount of biodegradable organic matter in leachate

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Parameter	Units	Municipal Solid Waste	Industrial Waste
		Range	Range
pH	-	1.9 – 13.0	5.8 – 12.6
Electrical conductivity	uS/cm^2	3 – 92,900	275 – 65,700
Total dissolved solids (TDS)	mg/L	1 – 520,000	136 – 52,200
Total suspended solids (TSS)	mg/L	3 – 21,940	01 – 4,400
BOD	mg/L	2 – 561,000	b.d.l. (2)[a] – 14,400
COD	mg/L	10 – 83,000	b.d.l. (2) – 25,500
Total alkalinity ($CaCO_3$)	mg/L	1 – 30,900	61 – 4,078
Sulfate (SO_4^{2})	mg/L	1 – 64,703	1 – 2,130
Chloride (Cl^-)	mg/L	11.9 – 30,200	5 – 32,000
Phosphate (PO_4^{3-})	mg/L	0.01 – 885	b.d.l. (0.01)
Ammonia (NH_3)	mg/L	0.1 – 1,900	0.1 – 417
Nitrate + nitrite (NO_2^- + NO_3^-)	mg/L	0.01 – 165	b.d.l. (0.05) – 91
Total Kjeldahl nitrogen (TKN)	mg/L	b.d.l. (0.2) – 12,000	0.2 – 476
Sodium (Na^+)	mg/L	b.d.l. (1) – 13,000	13 – 17,200
Cadmium (Cd)	mg/L	b.d.l. (0.0002) – 255	b.d.l. (0.0002) – 0.058
Calcium (Ca)	mg/L	b.d.l. (0.5) – 3,810	30 – 8.820
Iron (Fe)	mg/L	0.005 - 7260	0.02 – 207
Lead (Pb)	mg/L	b.d.l. (0.0001) – 0.674	b.d.l. (0.0001) – 0.166
Magnesium (Mg)	mg/L	b.d.l. (0.1) – 7,170	4 – 6,500
Manganese (Mn)	mg/L	b.d.l. (0.001) - 252	b.d.l. (0.001) - 64
Nickel (Ni)	mg/L	b.d.l. (0.0002) – 46.8	0.001 – 8.3
Acetone	mg/L	b.d.l. (0.06) – 2,000	n.d.[b]
Benzene	mg/L	b.d.l. (0.001) - 10	b.d.l. (0.001) - 39

Example of Leachate Quality

Parameter		MSW Leachate		Edmonton Leachate (1)		Regina Leachate (2)		East Prince (NS) Leachate (3)	
	Unit	Min	Max	Min	Max	Min	Max	Min	Max
pH		1.9	13	7.2	12.6	7.59	7.92	7.12	8.92
BOD5	mg/l	2	561000	61	20900			4	52
COD	mg/l	10	83000	140	35000	310	370	376	743
Alkalinity as CaCO3	mg/l	1	30900	910	11000	730	1400		

1) West Edmonton leachate 2009

2) Regina - leachate tank 2016

3) East Prince Feb 2017

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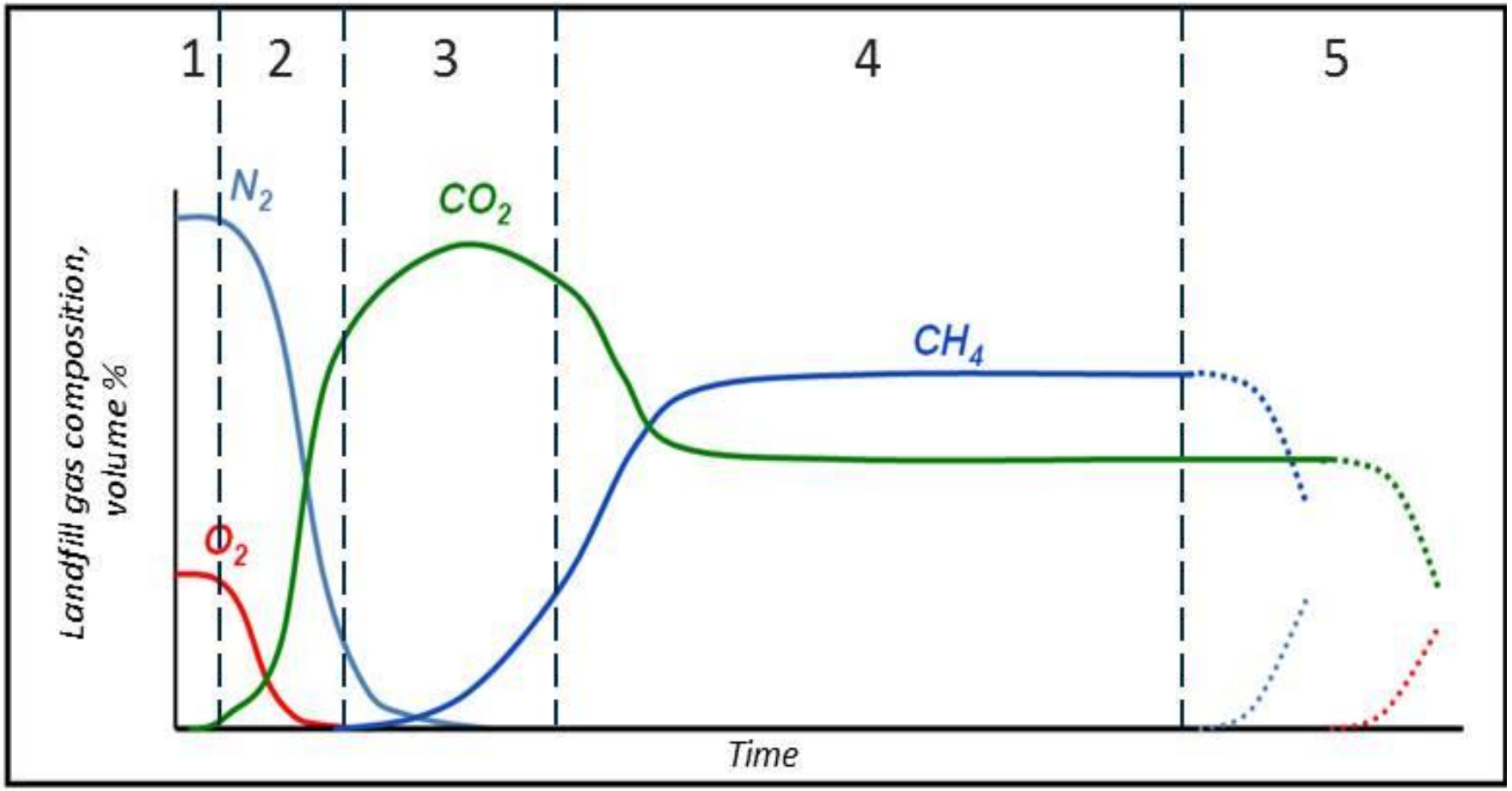
Leachate Life Cycle: Changes in gas production over time in a landfill. Decomposition phases 1-5



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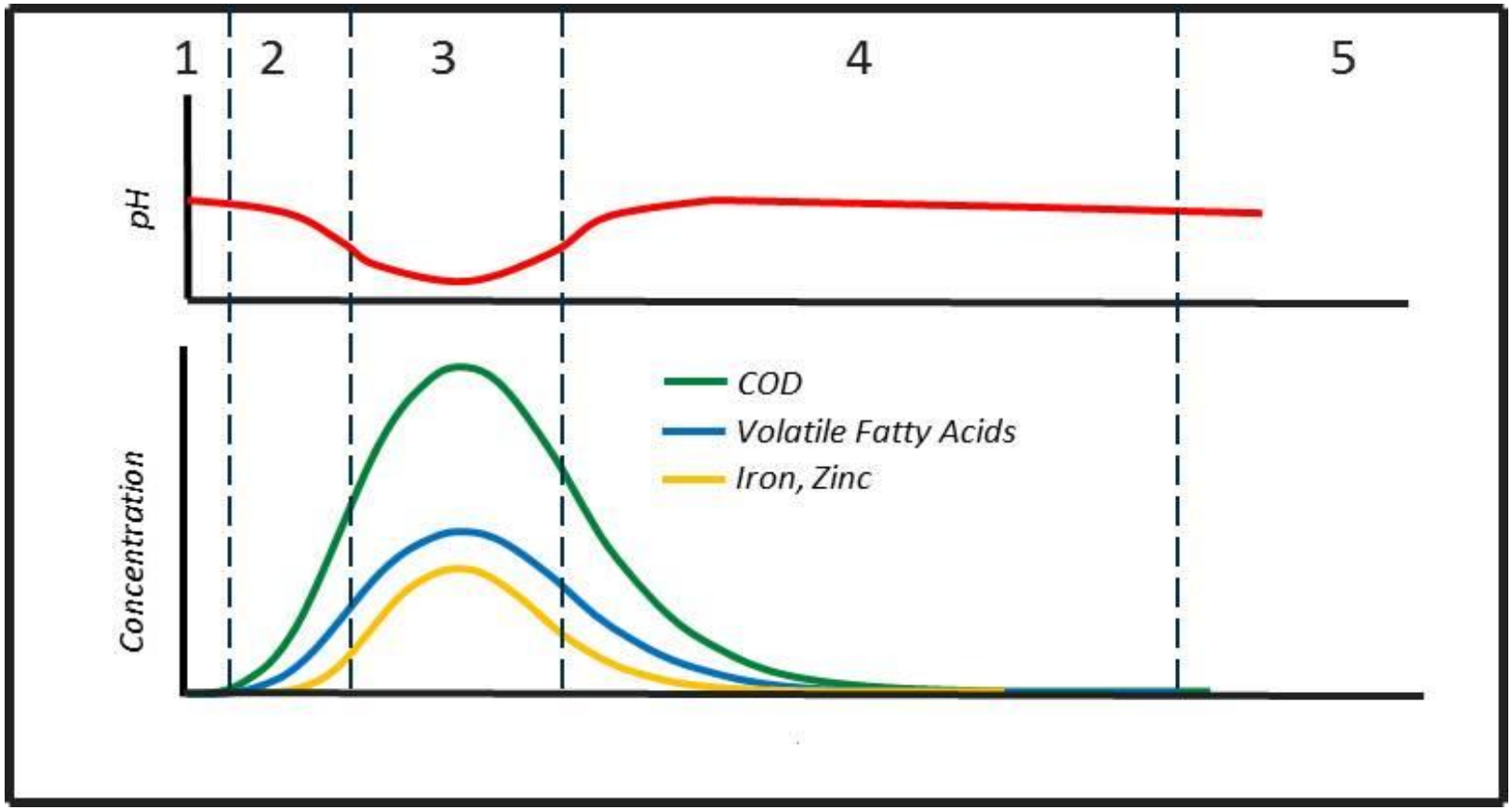
Leachate Life Cycle: Example of changes in some leachate parameters over time in a landfill. Decomposition phases 1-5



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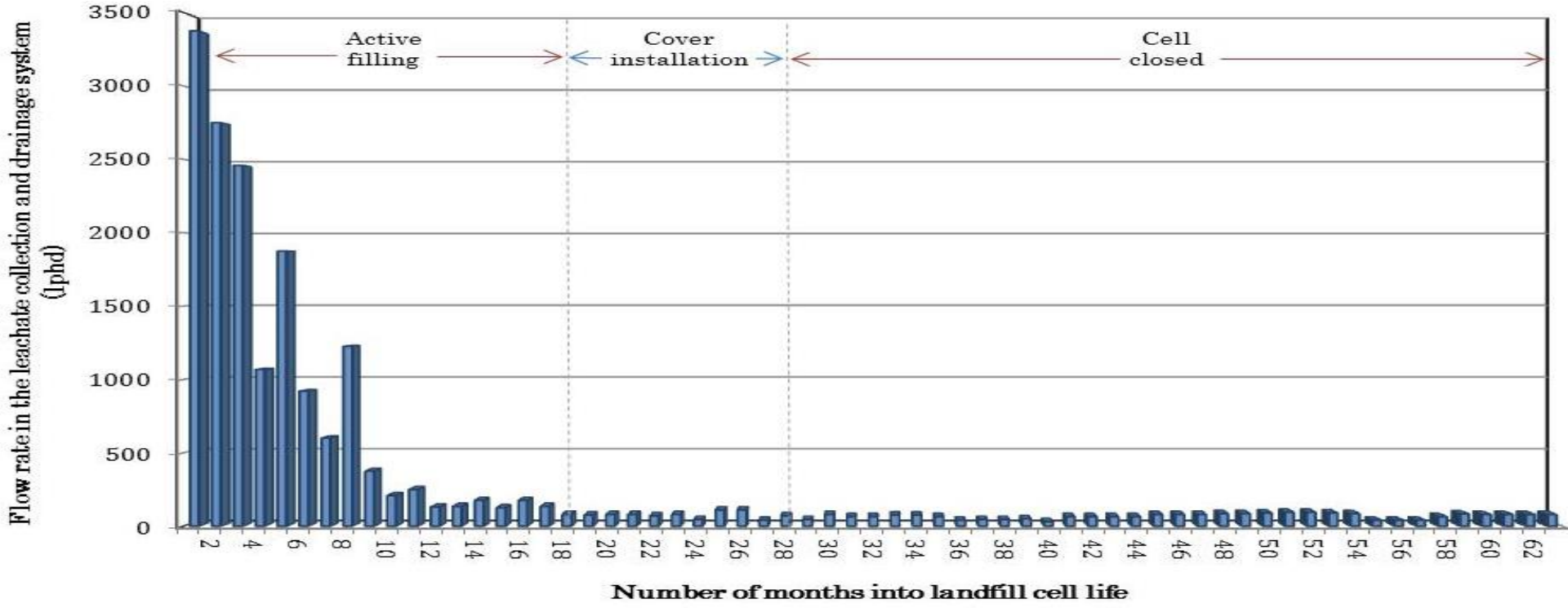
Leachate Production over Time

– Most landfills have a higher leachate production during active operation than post-closure.

– Production rates can be very high during initial operation of a new cell.



Landfill Operation: Leachate Monitoring

– Monitoring must be carried out through the entire life of the landfill to the end of the post-closure period.

– The leachate monitoring plan should include:
  - leachate levels and quality in the landfill, leachate ponds, and leak detection system;
  - leachate removal and treatment/disposal records;
  - surface and groundwater monitoring; and,
  - record keeping.

Monitoring helps Operators understand how the collection system is working, if liners are leaking, and the state of decomposition of waste

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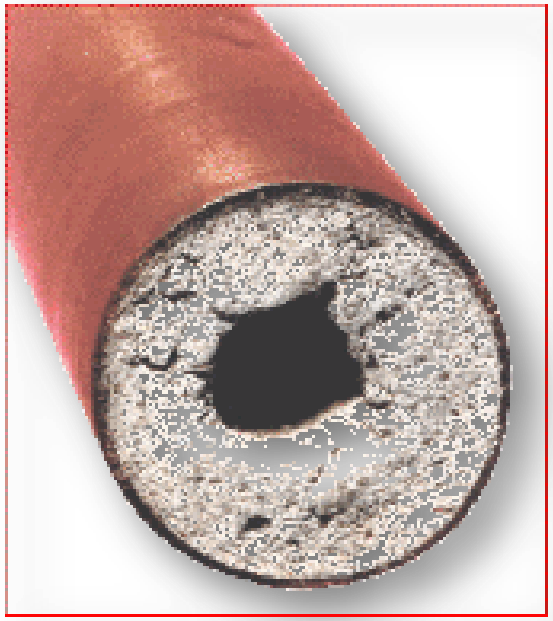
Leachate Collection System (LCS) Clogging

- Most common cause of LCS failure is pipe clogging
- Caused by buildup of material in:
  - Pipes (pipe walls or perforations)
  - Drainage layer (void spaces)
  - Geotextile filter layer (sedimentation)
- Results:
  - Increased head… non-compliance
  - Increase chances of leakage / seepage

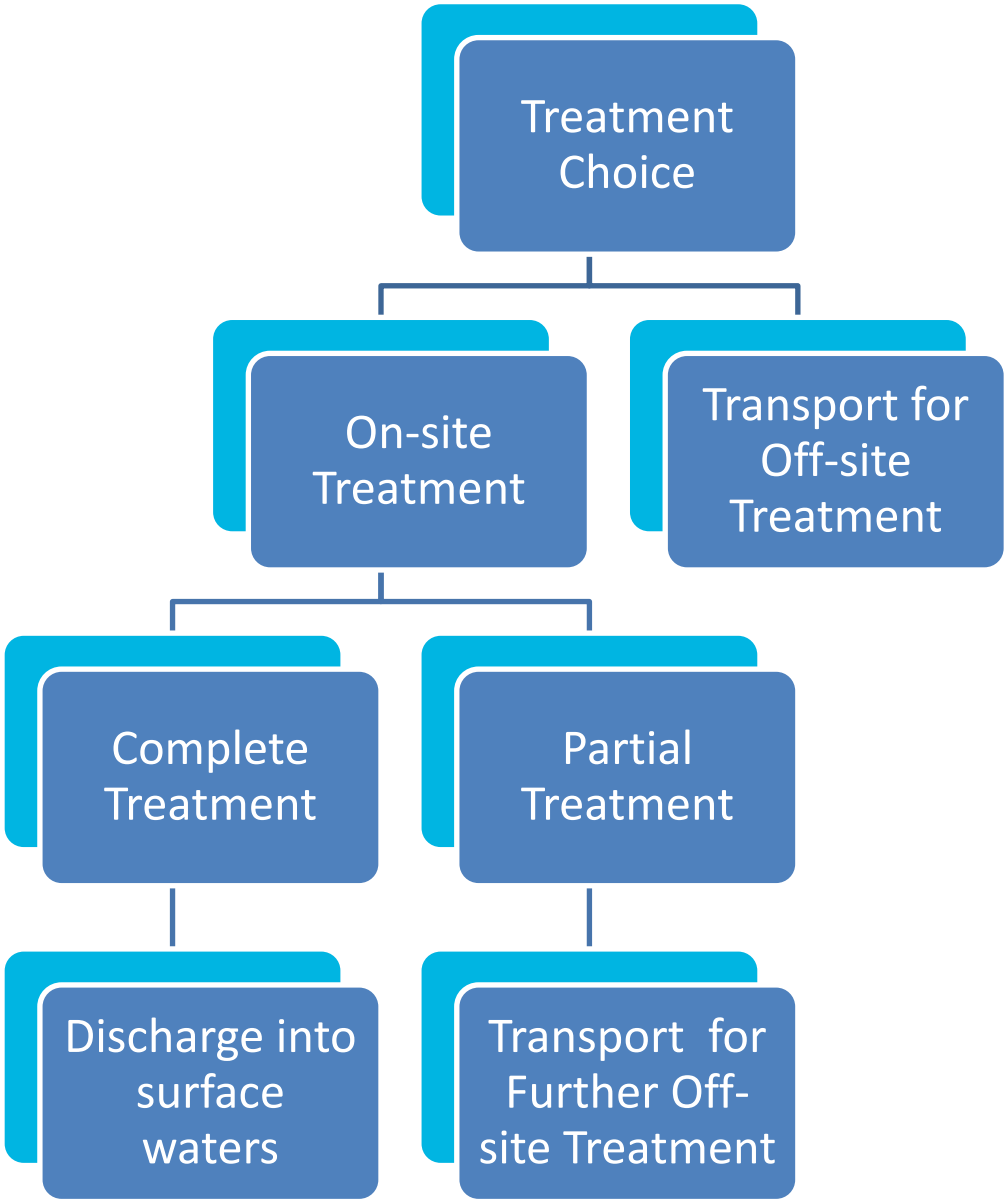
Leachate Collection System Clogging

- Where do the solids come from?
  - Particulate matter from waste and soil that leachate flows through
  - Biological material → particles or biofilm formation
  - Precipitation of dissolved chemicals
- Precipitation is strongly affected by pH!
- Most common precipitate in landfills is calcium carbonate



Leachate Treatment

Treatment Choice



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Leachate Treatment

– Treatment and disposal options:

- Pretreatment → Municipal sanitary wastewater system
- Transport/disposal to municipal wastewater treatment plant/lagoon
- Deep well disposal
- Treatment and discharge to the environment

Municipal Wastewater Treatment

- Leachate can be a high strength wastewater and may affect performance of WWTP
  - High organic loads
  - Methanogenic leachate will have high ammonia
  - Toxins
- The treatment plant must have:
  - Capacity to treat leachate volume
  - Ability to treat sludge from leachate
  - Ability to treat contaminants/characteristics of leachate
- Municipal bylaws may require surcharge for disposal or pretreatment

Municipal Wastewater Treatment

Parameter		Municipal Leachate		Municipal Wastewater		
	Unit	Min	Max	Weak	Medium	Strong
pH		1.9	13			
BOD5	mg/l	2	561000	110	220	400
TOC	mg/l			80	160	290
COD	mg/l	10	83000	250	500	1000
Total Nitrogen as N	mg/l			20	40	85
Total Phosphate as P	mg/l			4	8	15
Alkalinity as CaCO3	mg/l	1	30900	50	100	200
Iron	mg/l	0.005	7260			

Leachate Quality and Increased Organics Diversion

Building Better Business Case for Organics Diversion Programs

- Will lead to reduced landfill leachate treatment costs?
- Reduced organics to landfill (~30% of waste stream), reduced airspace consumption and extended landfill life
- Reduced landfill gas generation
- Improved leachate quality
- Social, environmental and financial benefits

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Premise - Removal of Organics

– Improves leachate quality which should:
  - Reduce leachate treatment and/or disposal costs
  - Reduce risk of significant groundwater contamination

– Reduces greenhouse gas generation

– Reduces dependency on foreign oil

– Increases nutrient composition of soil

– Decreases amount of waste to landfill

– Will reduce methane generation

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Case Studies

Hartland Landfill – Capital Regional District

- Strategy: phased approach
  - 2013: $20/tonne incentive
  - 2014: 20% surcharge at landfill on garbage loads containing kitchen scraps
  - 2015: complete ban on kitchen scraps
- Organics diversion includes: meat, bones, dairy products, grains, eggs, vegetables, fruit, soiled paper products
- Results:
  - Organic waste reduced to 75 kg/person from 120 kg/person in 2010

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Niagara Organics Collection Pilot Study 2013-2014

- Two co-collection scenarios were examined to determine impact on diversion rates/program costs:
  - Co-collection of kitchen organics/recyclables from 657 family households from one community;
  - Another scenario: 606 family households to examine weekly garbage collection/kitchen organics/leaf & yard wastes
- Results:
  - Region could offer weekly collection of recyclables and household kitchen organics for no difference in cost to current recycling collection program
  - Driver finished between 1-3 h earlier than during previous program.

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Happy Valley-Goose Bay Landfill

- No additional staff need for pilot project launched in 2015
- One objective is to mulch organic waste material (i.e. trees, shrubs, logs)
- Increase life of landfill by 25 years

Newfoundland and Labrador

- Divided into 8 management regions
- Focus on diverting traditional MSW organic materials from residential, industrial, commercial and institutional generators
- Objective to reduce amount of waste entering landfill by 50%

Emerging Contaminants in Landfills

What are Emerging Contaminants?

- Any chemical mixture or hazardous material with the *potential* to cause adverse human health, public safety, or environmental effects
- Any synthetic or naturally occurring chemical not typically monitored in the environment but *recently detected* in the environment
- Limited toxicity information available
- Concern with the length of exposure time
- Compounds designated as *candidate* Persistent Organic Pollutants (POPs)

Emerging Contaminants of Concern

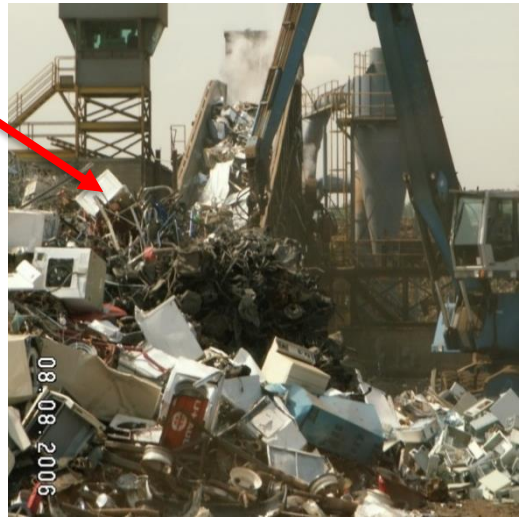
– Chemicals undergoing current screening in Arctic*:

- Perfluorocarboxilates (PFCAs)
- Perfluoroalkylsulphonates (PFSAs)
- Fluorotelomer alcohols (FTOHs)
- Perfluorosulphonamido-alcohols (PFTOHs)
- Siloxanes
- Organophosphate flame retardants

*Northern Contaminants Program

What if we have emerging contaminants in…

- Upholstery
- Mattresses
- Electronics
- White goods
- Vehicle parts
- Auto shredder residue



Source: Alex Stone, WA Department of Ecology

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Unique Challenges with Northern Dumpsites / Landfills

Landfills vs. Dumpsites…really???

- Landfills: geomembrane layers, leachate and gas collection systems
- Dumpsites: unorganized areas of rubbish collection
- Location, socioeconomic conditions, disposal methods, age, sampling and sorting procedures
- Evolution and changes in leachate composition driven by pH, O_2 and temperature to waste layers

Leachate Formation in a Northern Landfill/Dumpsite

- Leachate generation
- Typical contaminants
- No material completely impervious to leachate
- Improper leachate control may not be noticed until years later
- Water from precipitation, snow and waste percolates through rubbish layers
- Metals, organic compounds, (i.e. carcinogens, PFOS, EDCs, etc.), PBDEs, and dissolved organic matter

Challenges in the Canadian North

- If contaminant is detected in the Arctic, automatically *presume* it is persistent, subject to long range transport and likely bioacummulative
- Environmental pollution trends
  - Many declined in Arctic over past 20 years
  - Others influenced with no visible trend
- Criteria met for definition of persistent organic pollutants (POPs)
- Extent and degree of contamination poorly understood
- Release of contaminants
- Contaminants stored in: permafrost, sea ice, glaciers

Challenges in the Canadian North

- Problems with landfills (dumpsites) across Canada
- Canadian North (i.e. north of 60^{o} N)
- Most dumpsites unlined, some adjacent to water bodies, unauthorized dumping and/or uncontrolled access
- Northern dumpsites contain different waste streams than southern Canada
- Need to know nature and presence of emerging contaminant problem at dumpsites across the Canadian North

Emerging Contaminants in the Canadian Arctic

- Background on current POPs
  - Legacy POPs – 23 (historical use)
  - Bioaccumulate, persistent, toxic, long range transport

- Emerging chemicals
  - Many hazardous chemicals still being used commercially
  - Regulated nationally/internationally: BFRs, PFOAs, current used pesticides, heavy metals (Hg, coal burning, accidents)

What do these products have in common?

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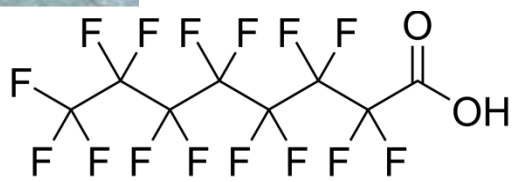
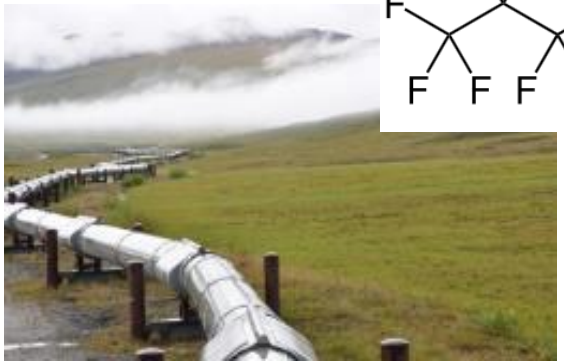
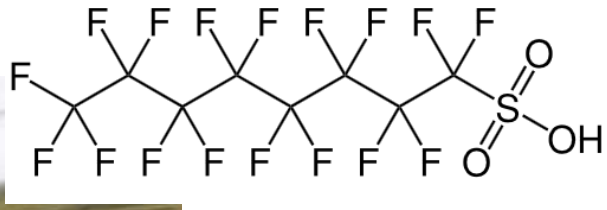
OR these…???







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Perfluorinated Compounds (PFCs)

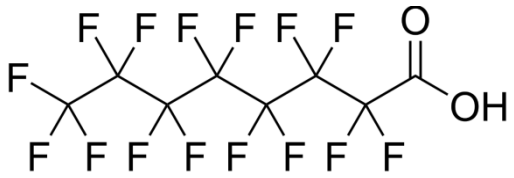
- Perfluorooctane sulphonate salts (PFOS) – used mostly in fire fighting foams
- Perfluorooctanoic Acid (PFOA) – used as emulsifier to produce fluoropolymers (PTFE or Teflon)
- Persistent, non degradable, toxic, bioaccumulate
- Uses: surface treatments, stain repellant, coating surfaces (non-stick cookware, electronic components), fire-fighting foams, waxes, food packaging

What are PFAS Compounds?

– Synthetic class of compounds used in manufacturing fluoropolymers

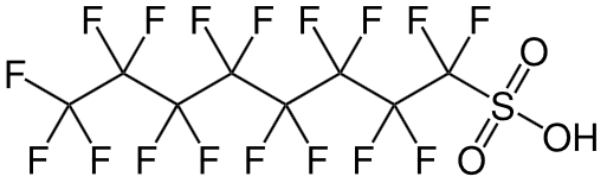
- PFOA – perfluorooctanoic acid and its principle salts, manufactured from 1947-present[1], 8 manufacturers phased out production by 2015

$C_8HF_{15}O_2$



- PFOS – perfluorooctane sulfonate, manufactured from 1949-2002[2]

$C_8HF_{17}O_3S$



– Used in the manufacturing of many articles of commerce

Perfluorinated Compounds (PFCs)

- Fully fluorinated hydrophobic linear carbon chain attached to 1 or more hydrophilic heads
- WWTP: non-ionic PFCs transform into PFOS and PFOA, with minimal removal efficiency
- Sewage sludge and hence crop uptake
- No known degradation; thus it is one of the most persistent chemicals
- Long half lives - years

Uncontrolled landfill

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Uncontrolled landfill cont'd…

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Uncontrolled landfill cont'd…

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Uncontrolled landfill cont'd…

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What Comes Next?

What Comes Next?

- Meta study to determine effectiveness of organics diversion ban in landfills across country
- Blanket organics ban at all landfills/dumpsites in Canada
- There may not be a facility in which to compare leachate strength with consideration to organics removal (i.e. apples to apples comparison)
  - Leachate variable over time
  - Landfill cells not ‘separate’ as waste can be filled over older cells

Questions and Thank You!

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