



PFAS Challenges in Agricultural Production: Livestock

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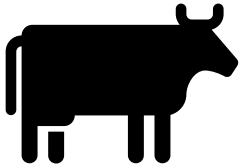


PFAS and Livestock

- Production Considerations and Challenges
- Livestock Research – ADME
- Livestock Research – Mitigation and Remediation
- Livestock Research – PFAS Analysis

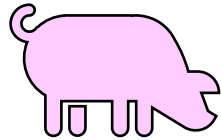


Multiple Types of Livestock



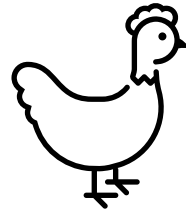
Bovine

- Beef (heifers, steers, cows)
- Veal calves
- Dairy cows
- Bulls
- Milk products



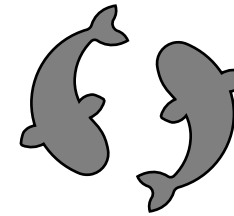
Porcine

- Market swine
- Roaster swine
- Boars, sows, stags
- Feral swine



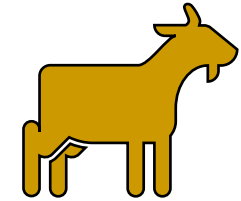
Poultry

- Young chickens (broilers/fryers)
- Young turkeys (fryers/roasters)
- Ducks
- Egg products



Aquaculture

- Siluriformes (catfish, bullheads)
- Salmon
- Shellfish
- Others



Other livestock

- Goats
- Sheep (adults and lambs)
- Rabbits
- Bison, deer, elk, etc

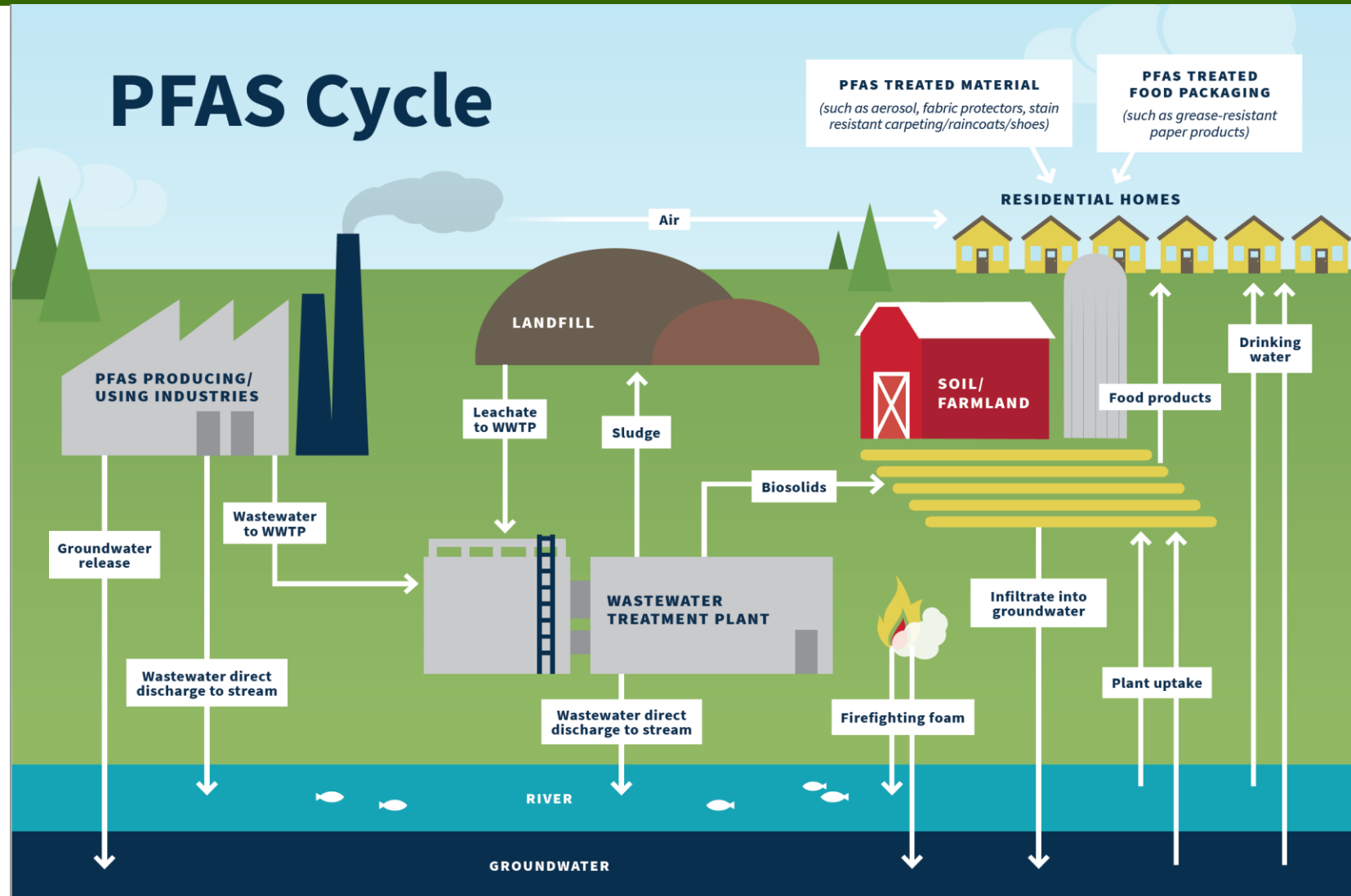
Contamination Inputs and Exposure Sources

Contamination Inputs

- Biosolids/Amendments
 - Municipal
 - Industrial (paper and textiles)
 - Manure
- Firefighting Foam

Exposure Sources

- Feed
- Water
- Soil
- Geographic
- Other sources



Production Practices

Intensive

- Close proximity housing, controlled diet, controlled environment
- Outdoor or indoor housing (feedlots, factory and battery farms)
- Feed and water sources, proximity to contamination

Semi-Intensive

- Close to wider proximity, semi-controlled diet with forage supplementation, semi-controlled environment
- Outdoor and indoor housing with some free range
- Feed sources (especially forage), water sources, possible exposure to environmental contamination with proximity

Extensive

- Long range, range lands/pastures, little to no control of diet or environment
- Outdoor
- Feed and water sources, probable exposure to environmental contamination with proximity



Free range housing system



Semi intensive housing system



Folding unit housing system



Battery cage & Deep litter system



Carcass and Waste Management

How contaminated are carcasses or manure

What is the volume of waste/carcasses

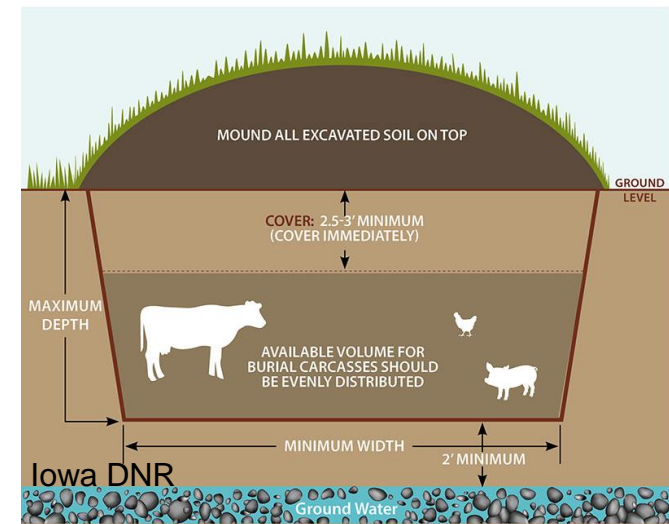
On-farm options

- Burial of carcasses not possible if contaminated
- Composting will concentrate PFAS into smaller volume but need to have safety measures in place to prevent environmental contamination
- Use of manure on croplands could cause additional issues

Offsite options

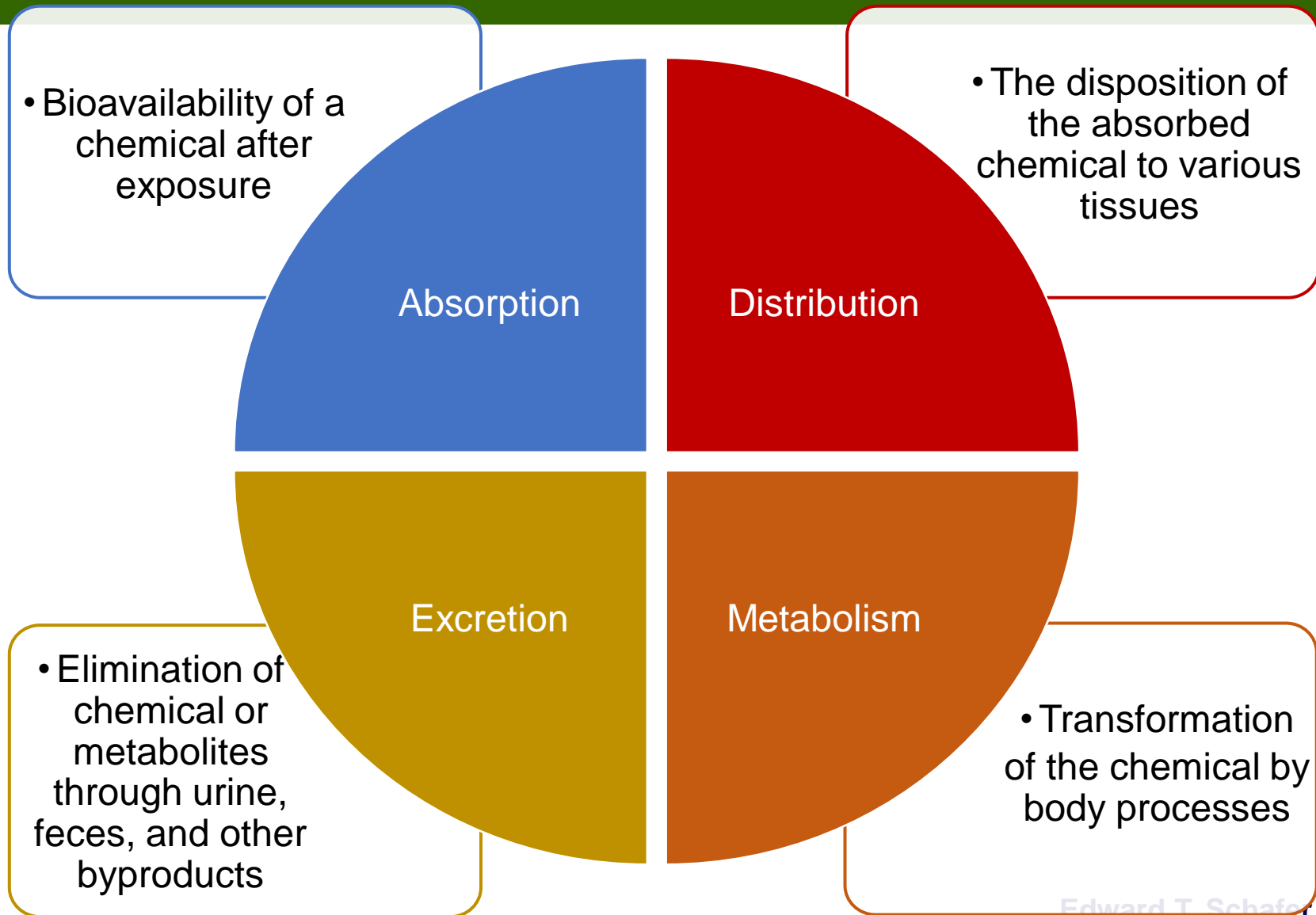
- Composting – same considerations as on-farm
- Land-filling – where allowed and appropriate with safety measures in place
- Incineration – incomplete combustion of PFAS compounds

Currently no complete abatement measures available



Livestock Research - ADME

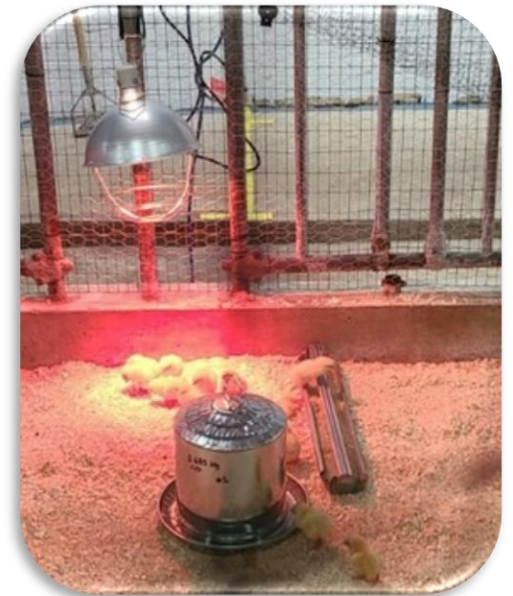
- Absorption, distribution, metabolism, and excretion studies provide data on the pharmacokinetics of a chemical exposure in an animal
- Data from studies are utilized for exposure and risk assessments
- These assessments inform typically in form regulation



Livestock Research - ADME

Challenges for livestock research

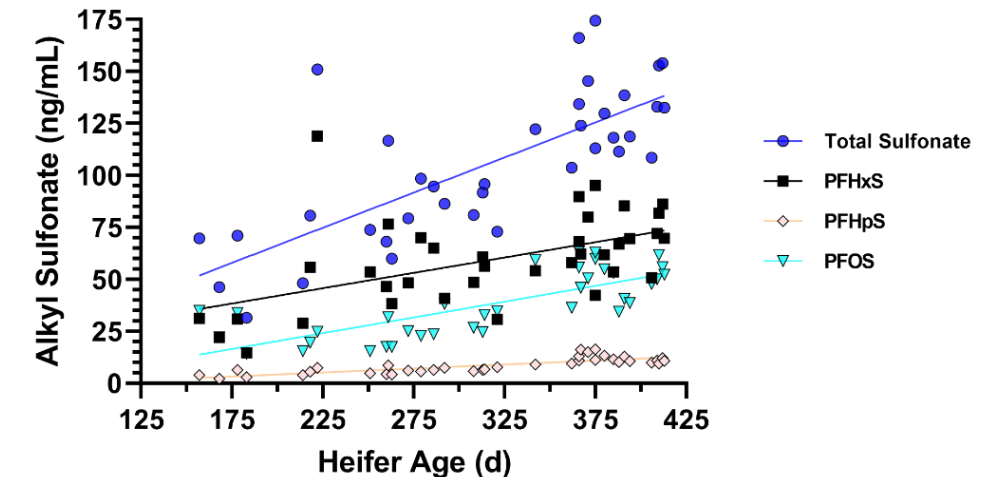
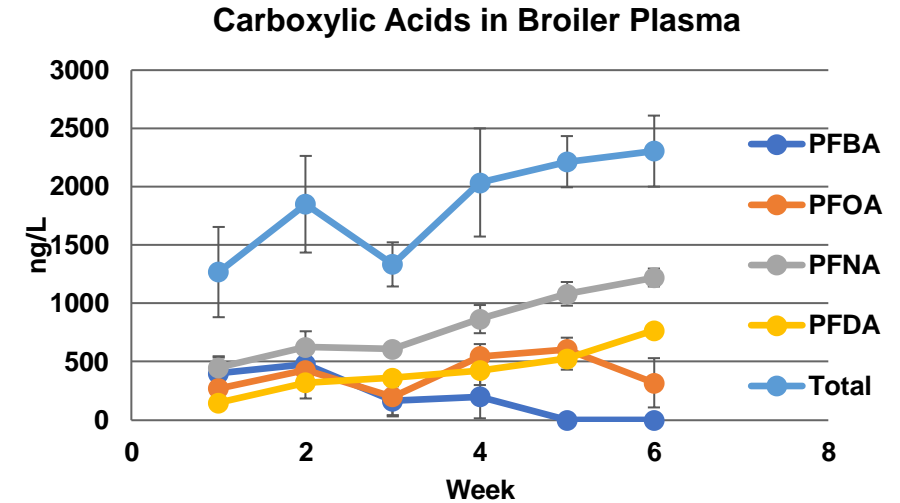
- Specie
- Housing
- Study Length
- Clean water and feed sources
- Exposure
 - Dose
 - Length of time
 - Which PFAS compounds
 - Incurred feed and water sources
- PFAS analysis cost and methods
- Waste and carcass management



Livestock Research - ADME

Data Gaps

- Some livestock species are missing ADME data needed for exposure and risk assessments
 - What is observed for one specie is not necessarily true for another
- Many PFAS compounds have not been studied in livestock species
- Bioavailability data from feed and water exposure are limited
- Waste and carcass management
 - Technologies for cleanup



Livestock Research – Remediation/Mitigation

Mitigating or preventing PFAS contamination of livestock

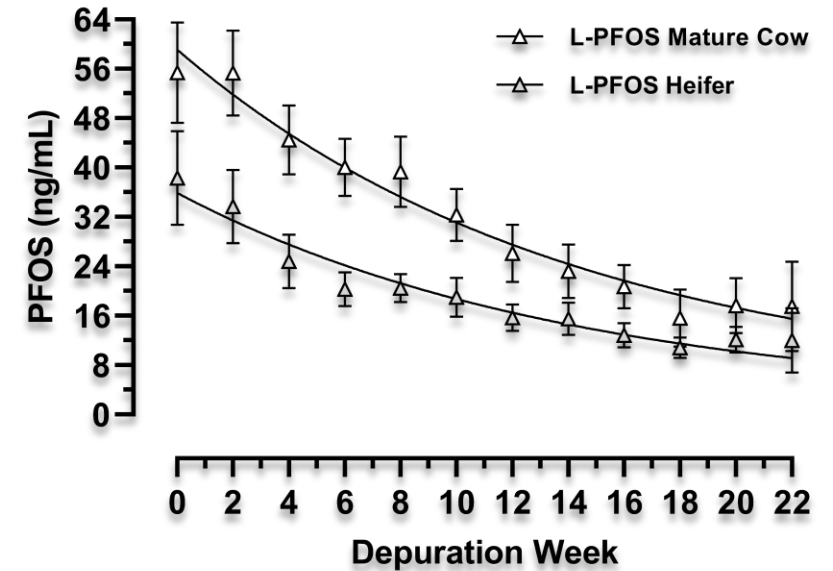
- Reduce or eliminate livestock exposure to PFAS
 - Provision of clean water and feed
 - Can be cost prohibitive and might not be viable long-term
 - Move animals to clean area/land or more confined feeding operations
 - Is this economically and logistically viable
 - Feed additives that can bind PFAS compounds before distribution into the tissue and increase excretion of PFAS as consumed



Livestock Research – Remediation/Mitigation

Remediating or clearance of PFAS from contaminated livestock

- PFAS Depuration
 - Time that PFAS clears naturally from body
 - Specie, compound, and half-life dependent
 - Level of contamination
 - Provision of clean water and feed
- Feed additives that will bind PFAS currently in the body and increase clearance
 - Possibly interrupt the enterohepatic recirculation

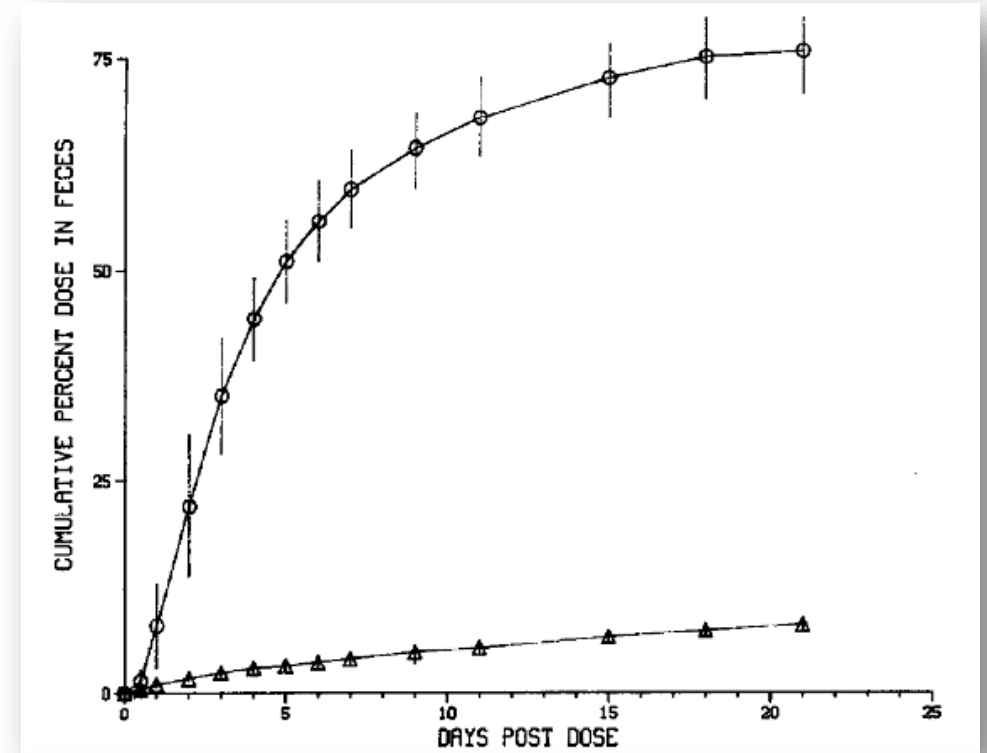


PFAS	Serum $T_{1/2}$	CI (95 th %)
	<i>wk</i>	<i>wk</i>
PFHxS	4.3	6.6
PFHpS	4.1	7.4
L-PFOS	9.8	46.1
3Me-PFOS	7.9	23.8
6Me-PFOS	10.4	97.3

Livestock Research – Remediation/Mitigation

Feed Additive Binder Considerations and Challenges:

- Safe for animals and humans if exposed
- Palatable and can be provided in feed
- Typically needs to be indigestible
- Binding Capacity and efficacy
 - Effective for wide range of PFAS
- Efficiency
- Cost effective
- Waste management
- **Currently there are only a few candidates being tested and only on specific species**
 - Need for additional candidates



FUNDAMENTAL AND APPLIED TOXICOLOGY 4, 972-976 (1984)

Cholestyramine-Enhanced Fecal Elimination of Carbon-14 in Rats after Administration of Ammonium [^{14}C]Perfluorooctanoate or Potassium [^{14}C]Perfluorooctanesulfonate

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Livestock Research – PFAS Analysis

Current Available Methods:

- EPA Method 1633 – fish tissues
<https://www.epa.gov/system/files/documents/2024-01/method-1633-final-for-web-posting.pdf>
- FDA C-010.03 – various foods including meat and animal products
<https://www.fda.gov/media/131510/download?attachment>
- USDA FSIS CLG-PFAS 2.04 – plasma and muscle of various species including meat animals and catfish
https://www.fsis.usda.gov/sites/default/files/media_file/documents/CLG-PFAS2.04.pdf



Method 1633

Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS



FDA U.S. FOOD & DRUG
ADMINISTRATION

**FDA Foods Program Compendium of Analytical Laboratory Methods:
Chemical Analytical Manual (CAM)**

United States Department of Agriculture

Food Safety and Inspection Service

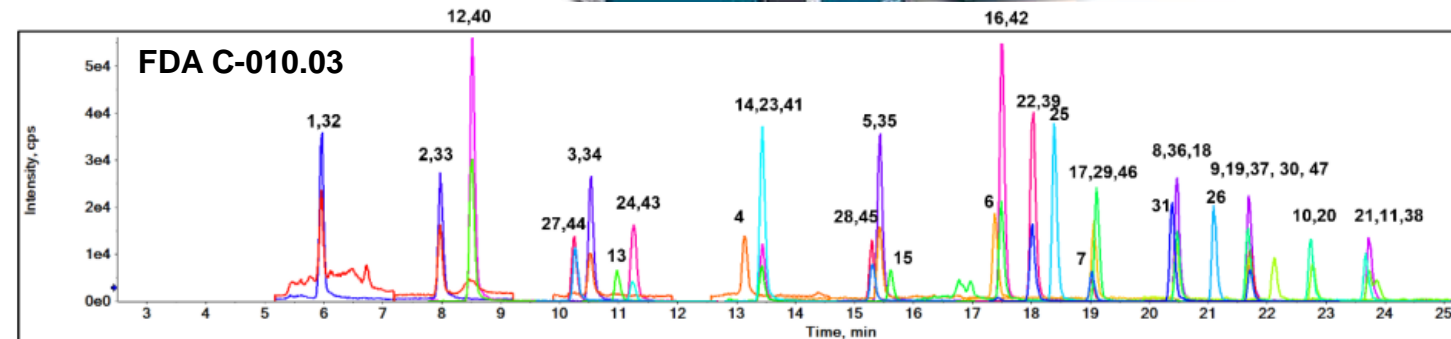
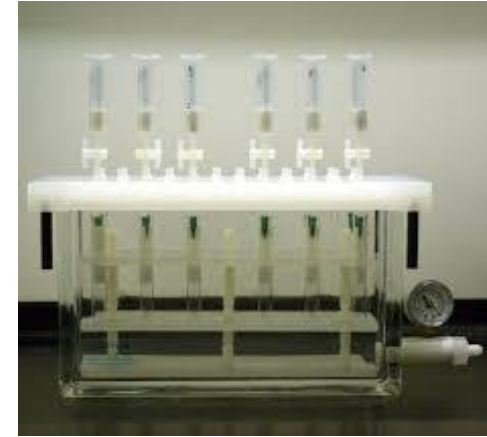
CLG-PFAS 2.04

**Screening, Determination, and Confirmation of
PFAS by UHPLC-MS-MS**

Livestock Research – PFAS Analysis

Considerations for Analysis Methods:

- Detection limits
- QA/QC requirements
- Compound recovery
- Number of PFAS compounds
 - Availability of isotopically labeled internal standards
- Efficiency
 - Extraction and analysis
- Robust
- Low Cost
- Wide range of covered matrices
- Validation
 - Single lab vs Multi-lab



Thank You!

