Is anything safe? Basics of risk assessment in the era of PFAS

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1

1938- Roy Plunkett invented PFAS

- And these compounds have been in use since the 1940s
- We have only been able to detect them in samples in the last 20+ years
- As with many of the new COC (contaminants of concern) they aren't new at all
- **All of the long term studies on biosolids have unintentionally also studied PFAS**

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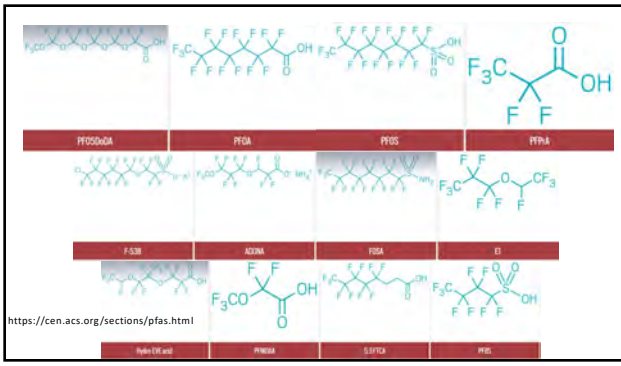

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Ubiquitous

Glüge et al. 2020

Table 1 Industry branches and other use categories where PFAS were or are employed. The numbers in parentheses indicate the number of subcategories. No parentheses indicate no subcategories

Industry branches	
Aerospace (7)	Mining (3)
Biotechnology (2)	Nuclear industry
Building and construction (5)	Oil & gas industry (7)
Chemical industry (8)	Pharmaceutical industry
Electroless plating	Photographic industry (2)
Electroplating (2)	Production of plastic and rubber (7)
Electronic industry (5)	Semiconductor industry (12)
Energy sector (10)	Textile production (2)
Food production industry	Watchmaking industry
Machinery and equipment	Wood industry (3)
Manufacture of metal products (6)	

Other use categories	
Aerosol propellants	Metallic and ceramic surfaces
Air conditioning	Music instruments (3)
Antifoaming agent	Optical devices (3)
Ammunition	Paper and packaging (2)
Apparel	Particle physics
Automotive (12)	Personal care products
Cleaning compositions (6)	Pesticides (2)
Coatings, paints and varnishes (3)	Pharmaceuticals (2)
Conservation of books and manuscripts	Pipes, pumps, fittings and liners
Cook- and bakingware	Plastic, rubber and resins (4)
Dispersions	Printing (4)
Electronic devices (7)	Refrigerant systems
Fingerprint development	Sealants and adhesives (2)
Fire-fighting foam (5)	Soldering (2)
Flame retardants	Soil remediation
Floor covering including carpets and floor polish (4)	Sport article (7)
Glass (3)	Stone, concrete and tile
Household applications	Textile and upholstery (2)
Laboratory supplies, equipment and instrumentation (4)	Tracing and tagging (3)
Leather (4)	Water and effluent treatment
Lubricants and greases (2)	Wire and cable insulation, gaskets and hoses
Medical utensils (14)	

4

Proprietary compounds

- More than 9,000 versions of PFAS
- Highly effective so can be used at low concentrations
- Not required to report use unless manufactured or used at very high rates (over 11 tons per year)

- **Only two versions: PFOA and PFOS have been phased out of production**

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For biosolids-

- It seems like PFAS is the equivalent to the proverbial :

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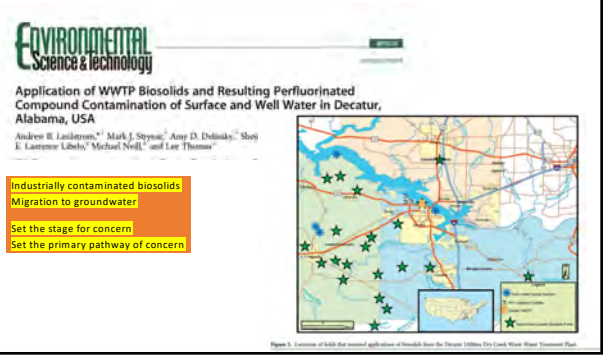

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https://www.theguardian.com/environment/2022/mar/22/i-dont-know-how-well-survive-the-farmers-facing-ruin-in-americas-forever-chemicals-crisis

9

Risk assessment basics
To understand biosolids and PFAS

End points- Acute Toxicity

Very popular in my husband's family

10

PFAS- chronic toxicity

https://www.atsdr.cdc.gov/pfas/health-effects/index.html

A large number of studies have examined possible relationships between levels of per- and polyfluoroalkyl substances (PFAS) in blood and harmful health effects in people. However, not all of these studies involved the same groups of people, the same type of exposure, or the same PFAS. These different studies therefore reported a variety of health outcomes. Research involving humans suggests that high levels of certain PFAS **may** lead to the following:

- Increased cholesterol levels
- Changes in liver enzymes
- Small decreases in infant birth weights
- Decreased vaccine response in children
- Increased risk of high blood pressure or pre-eclampsia in pregnant women
- Increased risk of kidney or testicular cancer

11

Risk = Hazard x Exposure

Can work two ways

Low hazard requires
BIG EXPOSURE

12

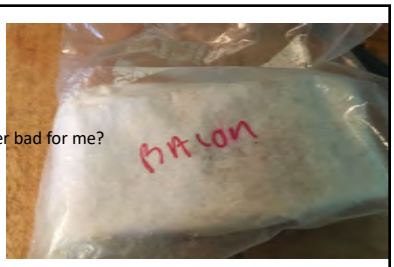
Risk = Hazard x Exposure

HIGH hazard requires small exposure

13

Let's talk bacon

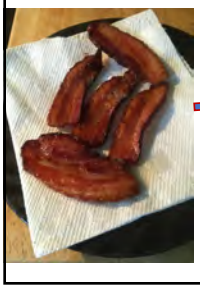
- Is bacon good for you?
- Is the bacon in my freezer bad for me?



14

For that bacon to be bad- you have to eat it

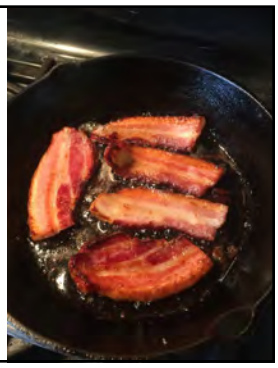
You need a pathway



15

And you have to consider

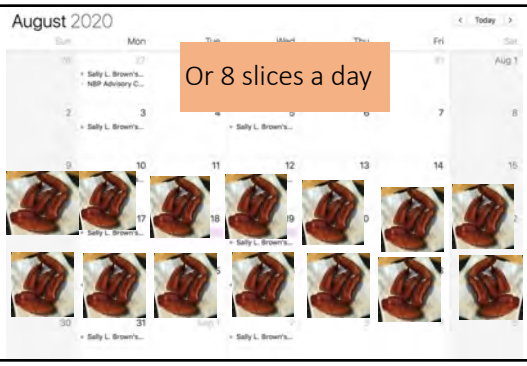
- Dose- response curve



16

If you have 1 slice every 2 weeks

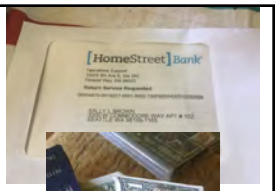
17

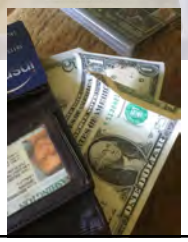


18

How much of total is available to do harm:
Making bacon- aka money

- Not all of your assets are liquid
- It is hard to spend money from your IRA

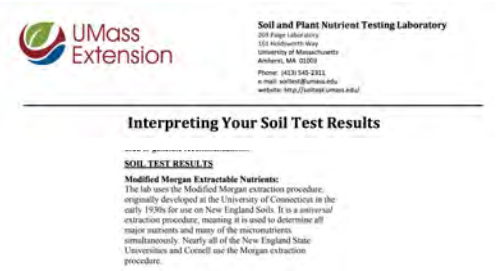




- Similarly- not all versions of a particular contaminant are as toxic or able to cause harm
- **Bioavailability** is the term used to describe portion of total that can cause harm or do good (depending)

19

Bioavailability is a very old concept


UMass Extension

Soil and Plant Nutrient Testing Laboratory

Interpreting Your Soil Test Results

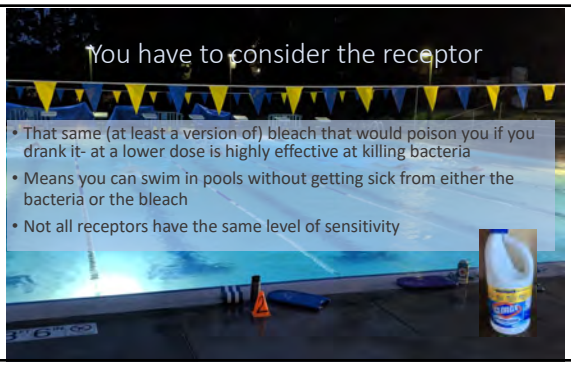
SOIL TEST RESULTS

Modified Morgan Extractable Nutrients:
The lab uses the Modified Morgan extraction procedure, originally developed at the University of Connecticut in the early 1930s for use on New England soils. It is a universal extraction procedure, meaning it is used to determine all major nutrients and many of the micronutrients simultaneously. Nearly all of the New England State Universities and Cornell use the Morgan extraction procedure.

20

You have to consider the receptor

- That same (at least a version of) bleach that would poison you if you drank it- at a lower dose is highly effective at killing bacteria
- Means you can swim in pools without getting sick from either the bacteria or the bleach
- Not all receptors have the same level of sensitivity



21

Food chain transfer
Rachel Carlson- Silent Spring

- DDT was applied to crops but impacted birds
  - (Target receptor)

22

Basics- 503 got them right

- Equation- Risk= hazard x exposure
  - Two kinds of risk- acute versus **chronic**
    - We are concerned with **chronic**
  - **Identify the individual at risk**
    - **Endpoint- or potential hazard**
  - **Identify the pathway of exposure**
    - **Identify the point where damage starts to occur (dose response curve)**
  - **Consider the bioavailability of the contaminant**
- **Apply these to the new class of chemicals (PPCPs)**

23

Emerging contaminants
(Pharmaceuticals and personal care products)
Daily home exposure- (no biosolids in the house)

- Found papers that back calculated home exposure based on the concentration in your urine
- Turns out after you wash with antimicrobial soaps, the stuff turns up in your pee in less than an hour

24

TCC and TCS- triclocarban and triclosan

- TCC- is an antimicrobial
- It, and TCS were all the rage for decades
- Any product that said 'anti microbial' had one of the two
- TCS is still in toothpaste

25

To get equivalent of 1 day of home exposure to triclosan you would have to eat 3.8 tons of potatoes grown in biosolids

Although you can detect a range of pharmaceuticals and personal care products in municipal biosolids and biosolids based composts, concentrations are typically orders of magnitude lower than in products that we use in our homes.

In soils these compounds are tightly bound and not taken up by plants. A recent study tested potatoes grown in soil amended with biosolids for a range of compounds including the anti-microbial TCS. The concentration of TCS was below the detection limit. We used that detection limit to estimate how many potatoes you would need to eat to get the same amount of TCS that you would get in one day using products like Colgate toothpaste

https://mountainviewumc.org/outreach/in-our-community/pota

26

PFAS/ PFOA current concern

I would argue that it fits into the home exposure category

27

So what is the pathway?

28

'Complete crisis' as PFAS discovery upends life and livelihood of young Maine farming family

As of writing (Sept 2022) < 10 farms impacted
A strong history of pulp mills making coated paper and food service paper
Elevated groundwater concentrations 400 x ME limit
EPA = 70 ppt
ME = 20 ppt

29

PFOA/PFOS for example

- Sepulvado et al., 2011
- 100 years of biosolids over 33 years
- 2004 biosolids
  - PFOS 80-219 ng g
  - PFOA 8-68 ng g
- Long chain PFAS is much less mobile than predicted when applied in a biosolids matrix

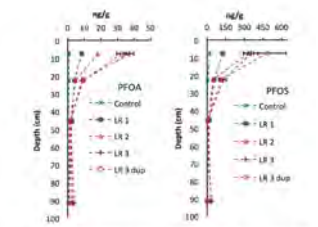
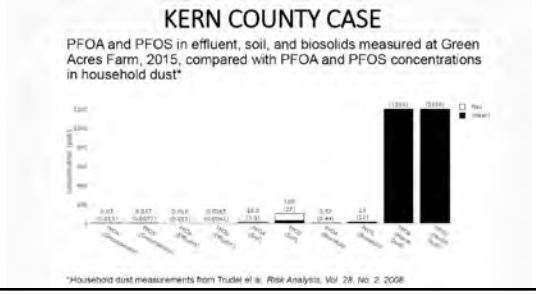


Figure 3. Concentrations of PFOA and PFOS with depth in the long-term plots at various loading rates. Control = 0 Mg/ha, LR 1 = 553 Mg/ha, LR 2 = 1109 Mg/ha, and LR 3 and LR 3 dup = 2218 Mg/ha (on dry weight basis).

30

Ian Pepper, U AZ



31

My local paper

- Groundwater contamination
  - Typical near military sites
  - Airports
  - Was the primary exposure pathway in ME

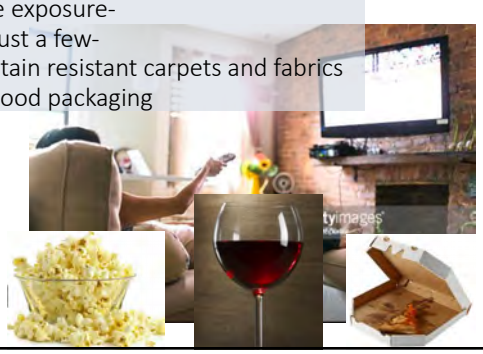
32

Home exposure-

Just a few-

Stain resistant carpets and fabrics

Food packaging



33

Serving 69 million daily worldwide

34

Who is this and what do you think about when you see her picture?

35

Helpful graphic from CASA

36

Human Blood ppb

CDC Data

	PFOA	PFOS
1999	5	30
2012	2	6

Note that these are only measures of the banned compounds, they do not include the full suite of PFAS compounds

37

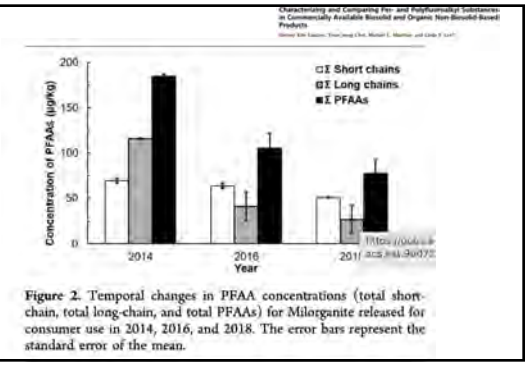


Figure 2. Temporal changes in PFAA concentrations (total short-chain, total long-chain, and total PFAAs) for Milorganite released for consumer use in 2014, 2016, and 2018. The error bars represent the standard error of the mean.

38

Ban the biosolids or the dental floss?

As a result of concerns about perfluorinated compounds in biosolids many states are considering bans on their use-

The concentration of perfluorinated compounds in many dental floss products is 16 ppb

The concentration of perfluorinated compounds in the biosolids was 48 ppb

A recent study showed a direct correlation between use of fluorinated dental floss and increased body burden of these compounds

No such correlation has been seen for biosolids or composts

39

Which cake would you rather eat?

As a result of concerns about perfluorinated compounds in biosolids many states are considering bans on their use-

The FDA recently sampled a range of food products for PFAS compounds. The chocolate cake tested had concentrations of 17 ppb

The concentration of perfluorinated compounds in biosolid, often referred to as 'cake' was 48 ppb

As this comparison shows, home exposure to these compounds is far greater than any potential exposure from biosolids

40

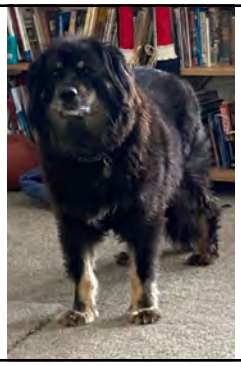
Fecal Excretion of Perfluoroalkyl and Polyfluoroalkyl Substances in Pets from New York State, United States

85 +/- 94 ng g (ppb)

- What are likely sources?

CASA biosolids 27 ppb

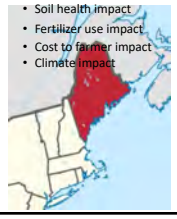
- How much biosolids would Soph have to eat?



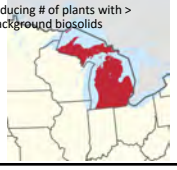
41

A tale of two states

- Maine aka Ground zero
  - Banned land application
    - Doubled or > costs of biosolids
    - Soil health impact
    - Fertilizer use impact
    - Cost to farmer impact
    - Climate impact



- Michigan
  - Required municipalities test
    - If above a background level required source control
    - If below a background level BAU
    - Source control has been effective in reducing # of plants with > background biosolids



42

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