

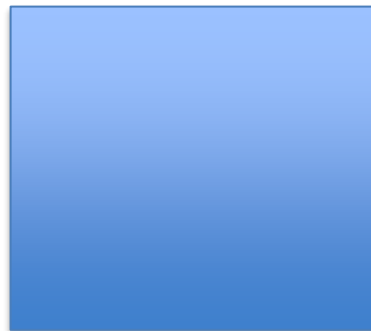
RESEARCH TO STAY CONNECTED, CURIOUS, AND AHEAD OF THE GAME

Patrick McNamara, PhD, PE

Professor, Dept of Civil, Construction & Environmental Engineering, Marquette University
PFAS & Residuals Research Lead, Black & Veatch

Stay Connected

Red or Blue?





Either, Or

- We quench up →
- Can't take in facts →
- Emotion overrides →
- Can't see entire picture →

“Good or bad” is our natural tendency

Are Biosolids Good or Bad?

- Good: resource for C, N, P
 - Bad: full of society's toxins
-
- If always good, only takes one bad site to say they are all bad

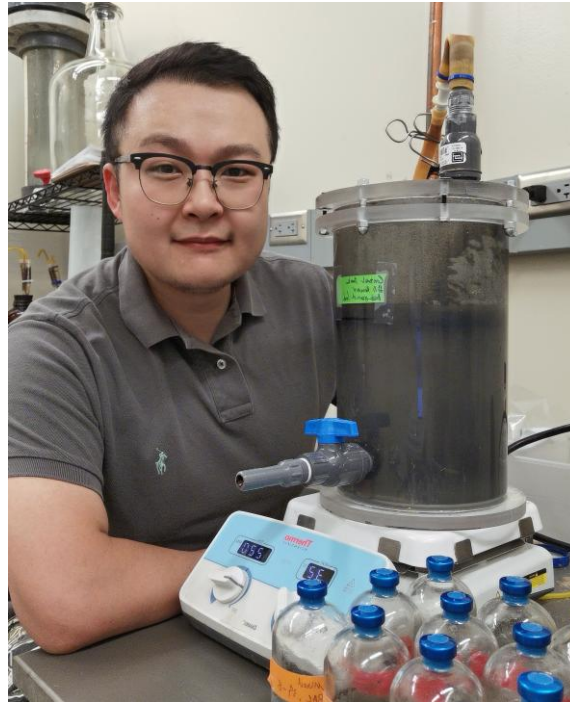


PFAS....Good or Bad?

- High exposure to high levels → cancer clusters
- Pacemakers, not lighting on fire

- If always bad, dose does not matter

What if it's both...what if it depends?



Zihao Lu, PhD Candidate

Some of my most vivid childhood memories come from our evening walks along the river. Part of the river flowed clear and calm, but another part, downstream from the factory, was cloudy, foamy, and smelled sharply of chemicals. As a child, I didn't yet understand industrial pollution, but I understood that the river was hurting. As I grew older, I learned the uncomfortable truth: the factory that supported my family was also polluting the environment we relied on. This shaped my understanding of environmental issues, not as simple conflicts between "good" and "bad" actors, but as complex tradeoffs tied to survival, livelihoods, and opportunity.

Jesuit Indifference

- In Jesuit (or Ignatian) philosophy, **indifference** does not mean apathy, detachment, or not caring. Instead, it is a state of deep inner freedom and being equally ready to accept things or let them go
- Challenges our natural tendency to cling to things that make us feel safe, comfortable, or in control
- Research – being open to what results might tell us...as well as what we research

Stay Curious



Enter: Pyrolysis



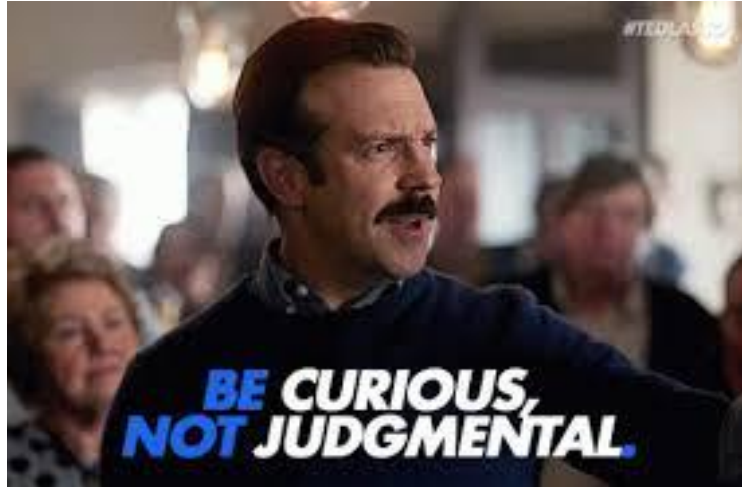
From MMSD's 2035 vision

- Meet a net 100% of MMSD's energy needs with renewable energy sources
- Meet 80% of MMSD's energy needs with internal, renewable sources
- Reduce MMSD's carbon footprint by 90% from its 2005 baseline



I was judgmental

- Dan, aren't we just heating sludge? Can we even publish this?



- Pat, just do good work. Also, we are going to work with an agronomist.

Connections to Drive Research

- Industry

- Utilities



- Universities

Can biosolids-derived biochar be used as a soil amendment?

- Moisture holding capacity
- Carbon sequestration
- Less water extractable P than biosolids

Biochar as a Beneficial Soil Amendment

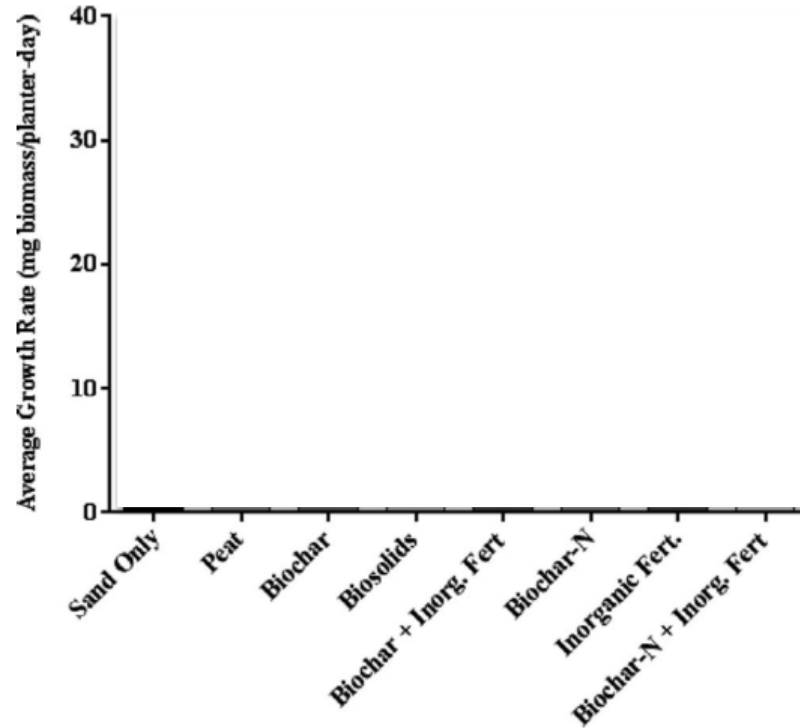


Figure 3—Average growth rate of Kentucky bluegrass biomass. Biomass was measured immediately after trimming to a height of 1 in.

Carey D.E., McNamara, P.J., Zitomer, D.H. 2015. Biochar from Pyrolysis of Biosolids for Nutrient Adsorption and Turfgrass Cultivation. *Wat. Env. Res.* 87 (12), 2098-2105.

Biochar as a Beneficial Soil Amendment

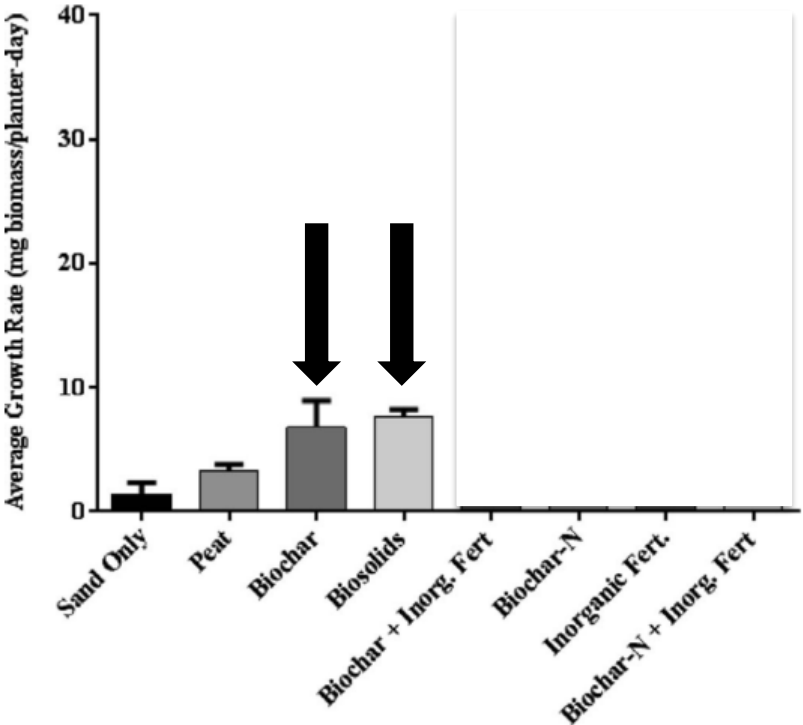
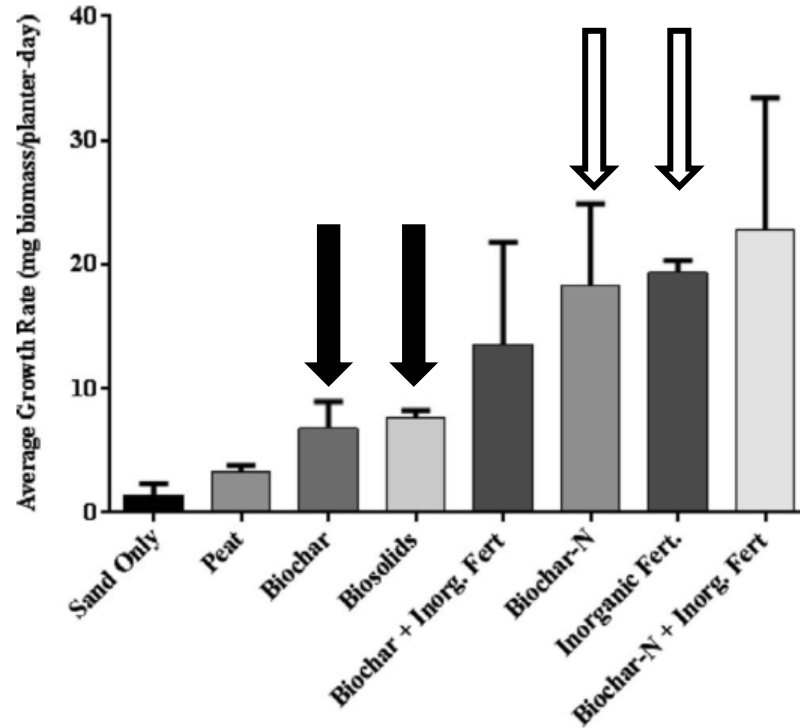


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Biochar as a Beneficial Soil Amendment



- Need to test specific biochar with specific application

Figure 3—Average growth rate of Kentucky bluegrass biomass. Biomass was measured immediately after trimming to a height of 1 in.

Biochar as a Beneficial Soil Amendment



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Biochar from Pyrolysis of Biosolids for Nutrient Adsorption and Turfgrass Cultivation

[D. E. Carey](#), [P. J. McNamara](#), [D. H. Zitomer](#) ✉

First published: 01 December 2015 | <https://doi.org/10.2175/106143015X14362865227391> |

[VIEW METRICS](#)

Marquette University ✉

Cited 105 times

Important because it was information we did not have

MMSD vision set a lot of work in motion

- Thermal treatment
- Energy balances
- Fate of contaminants

Pyrolysis of Dried Wastewater Biosolids Can Be Energy Positive

Patrick J. McNamara¹, Jon D. Koch², Zhongzhe Liu¹, Daniel H. Zitomer^{1*}

Pyrolysis of wastewater biosolids

T.C. Hoffman, D.H. Zitomer, P.J. McNamara

Department of Civil, Construction and Environmental Engineering, Marquette University

HIGHLIGHTS

- Biochar was significantly less estrogenic than anaerobically digested and primary biosolids.
- Pyrolysis conducted at 400°C or greater removes more than 95% of estrogenicity from biosolids.
- The cleanup method developed had moderate recovery of E2, but reduced YES toxicity of biosolids.




GRAPH



Autocatalytic Pyrolysis of Wastewater Biosolids for Product Upgrading

Zhongzhe Liu,[†] Patrick McNamara,[†] and Daniel Zitomer^{*,†}

[†]Department of Civil, Construction and Environmental Engineering, Marquette University, Milwaukee, Wisconsin 53233, United States

 Supporting Information

Environmental Science Water Research & Technology



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Cite this: *Environ. Sci.: Water Res. Technol.*, 2016, 2, 282

Emerging investigators series: pyrolysis removes common microconstituents triclocarban, triclosan, and nonylphenol from biosolids[†]

J. J. Ross,^a D. H. Zitomer,^a T. R. Miller,^b C. A. Weirich^b and P. J. McNamara^{*,a}

MMSD asked and answered questions
before they mattered

MMSD Stayed Ahead of the Game





Science of The Total Environment

Volume 444, 1 February 2013, Pages 515-521



Evaluation of a model for the removal of pharmaceuticals, personal care products, and hormones from wastewater

Benjamin D. Blair ^a, Jordan P. Crago ^b, Curtis J. Hedman ^c, Ronan J.F. Treguer ^d,
Christopher Magruder ^e, L. Scott Royer ^f, Rebecca D. Klaper ^a  

Unfunded WERF Proposal

Biosolids Pyrolysis Feasibility: Energy Balance and TOrC Removal

Why not diversify before we have to?

Why not have data before we need it?

Linda Lee was ready before we needed her

[Environmental Science & Technology](#) > Vol 41/Issue 23 > Article

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ARTICLE | October 26, 2007

Biotransformation of 8:2 Fluorotelomer Alcohol in Soil and by Soil Bacteria Isolates

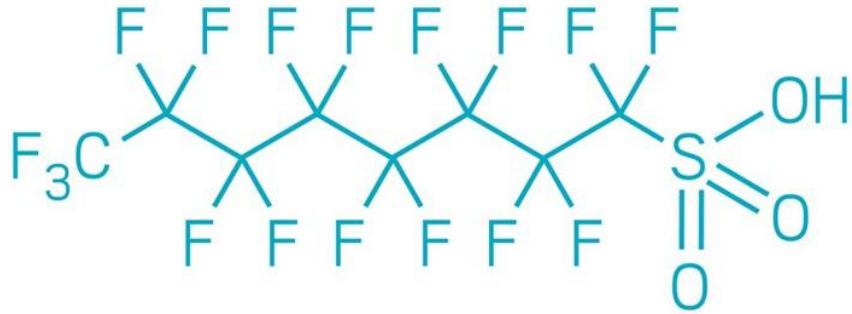
Jinxia Liu[†], Linda S. Lee^{**†}, Loring F. Nies[‡], Cindy H. Nakatsu[†], and Ronald F. Turco[†]

Stay Curious → Sabbatical

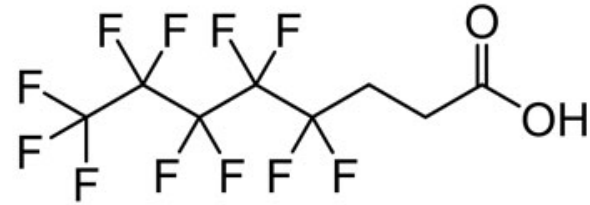
Project #5211

Understanding the Value Proposition for Thermal Processes to Mitigate PFAS in Biosolids

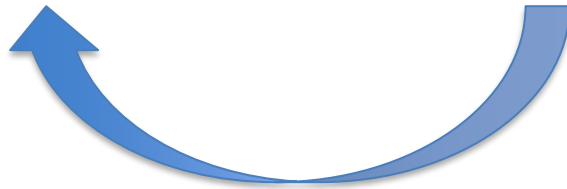
Per- and Polyfluoroalkyl Substances (PFAS)



Perfluorooctanesulfonic acid
(PFOS)

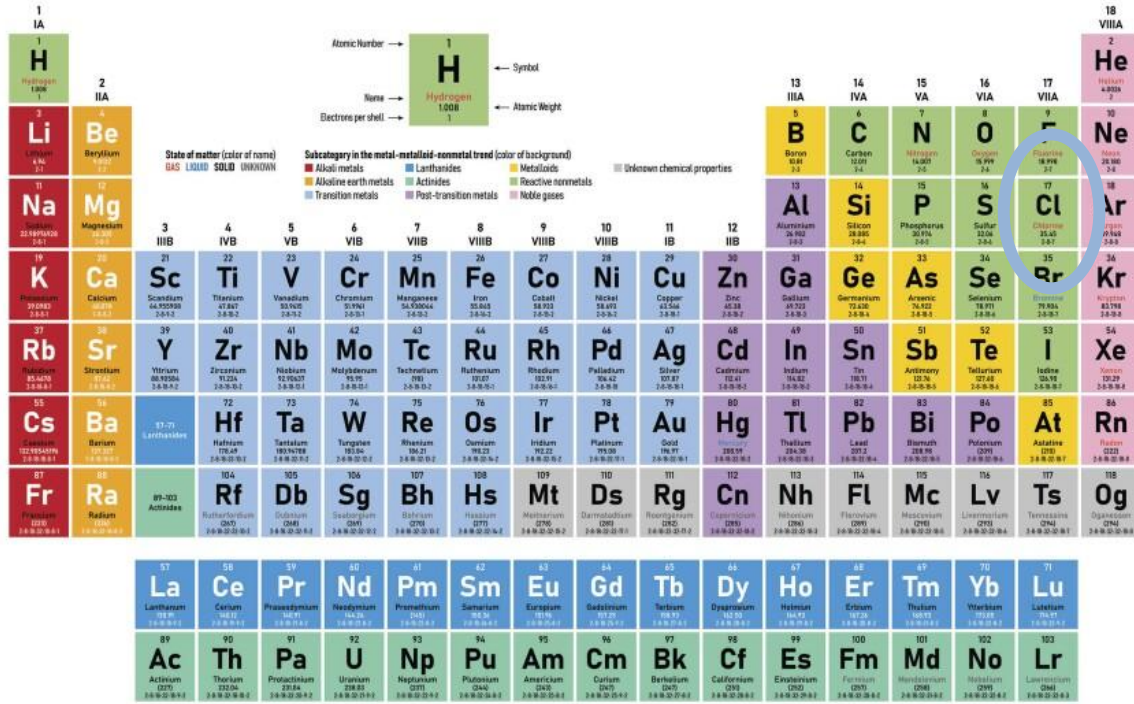


5:3 Fluorotelomer Carboxylic Acid
(5:3 FTCA)



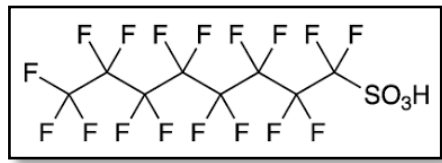
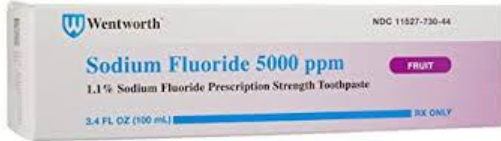
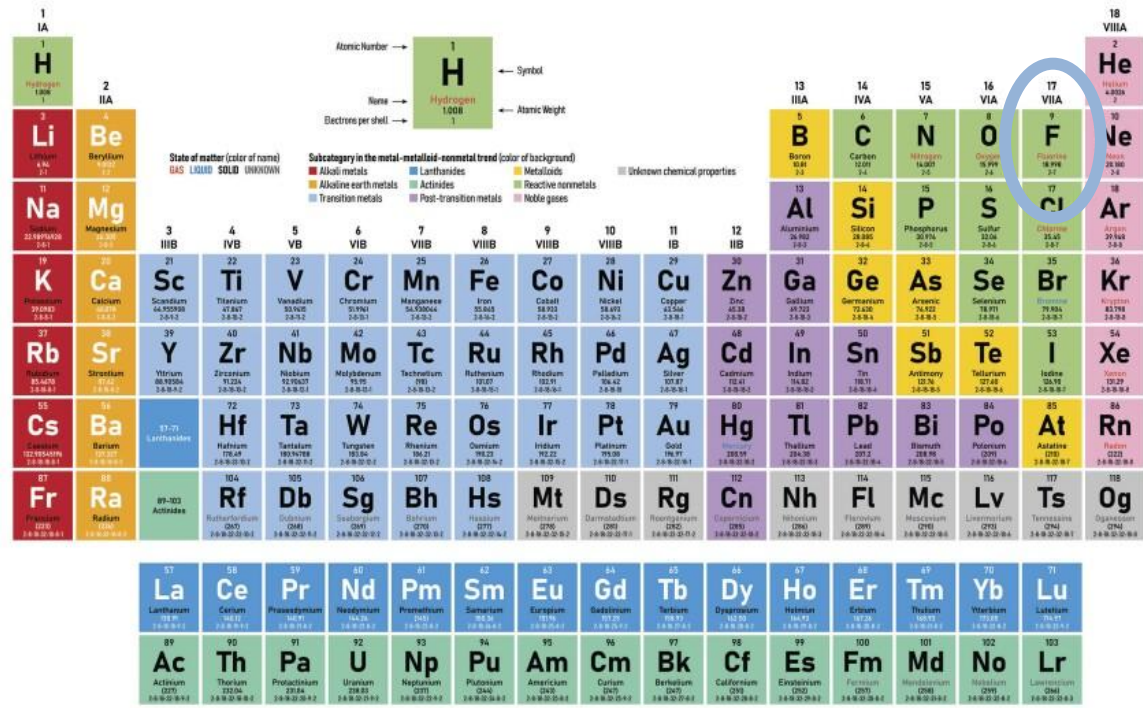
Is chlorine (Cl) in table salt the same as Cl in a pool?

Periodic Table of the Elements



Is fluorine (F) in toothpaste the same as F in PFAS?

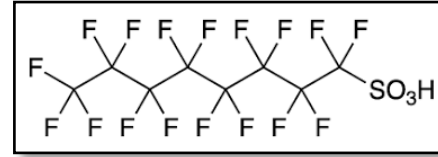
Periodic Table of the Elements



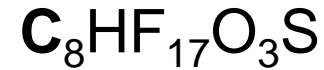
Is fluorine (F) in toothpaste the same as F in PFAS?



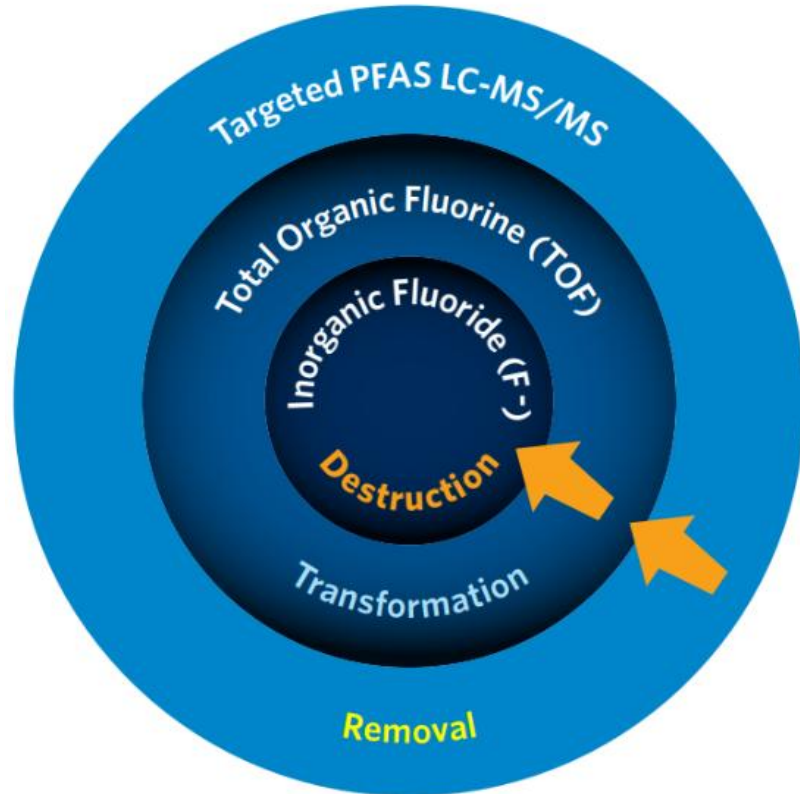
Inorganic



Organic



WRF 5211 - Understanding the Value Proposition for Thermal Processes to Mitigate PFAS in Biosolids



Research Objective: Establish mass balances for PFAS in biosolids across thermal process phases

“quantifying total organic fluorine (TOF) in conjunction with LC-MS/MS provides information on the extent of transformations”

“if the LC-MS/MS analysis reveals that a compound was removed, but the TOF values remain unchanged, then the reason the compound was not detected was due to its transformation into a different PFAS compound”

We want to do a mass balance on
PFAS across X....

let's use TOF

How many PFAS are there?

a. >7 million

b. >21,000

c. ~1,400

How many PFAS are there?

Per- and Polyfluoroalkyl Substances (PFAS) in PubChem: 7 Million and Growing

Emma L. Schymanski*, Jian Zhang, Paul A. Thiessen, Parviel Chirsir, Todor Kondic, and Evan E. Bolton*

a. >7 million

In 2021, the Organisation for Economic Co-operation and Development (OECD) revised the definition of PFAS to include any chemical containing at least one saturated CF_2 or CF_3 moiety.

b. >21,000 EPA's CompTox
Chemicals Dashboard

c. ~1,400 EPA's TSCA Section
8(a)(7)

Elucidating Unknown Organofluorine in Municipal Wastewater: A Mass Balance Approach including Fluorinated Pharmaceuticals

Pontus Larsson, Anna Kärrman, and Leo W.Y. Yeung*

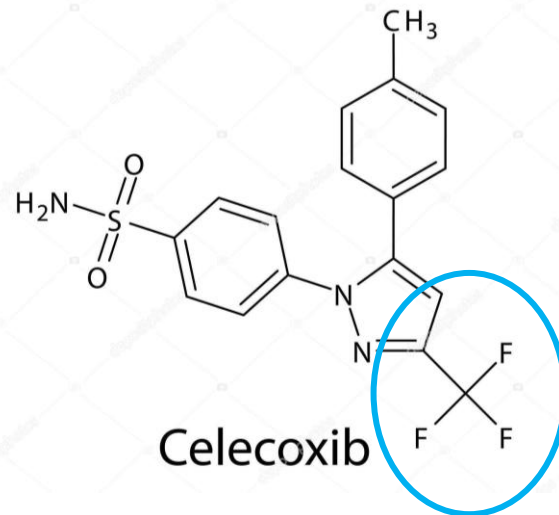


Cite This: *Environ. Sci. Technol.* 2026, 60, 6623–6634



Read Online

- Pharmaceuticals 28-42% EOF
- TOF captures single CF moieties
- single CF moieties are not considered PFAS in the U.S.
- TOF > PFAS



Targeted Methods

Project #5211

Understanding the Value Proposition for Thermal Processes to Mitigate PFAS in Biosolids



Jessie Calteux
Ph.D. Student
Marquette University

Project 5337

Breaking the Forever PFAS Cycle: Recycle Stream Treatment to Reduce PFAS Loading to WRRF Influent and

Project 5384

The Impact of Dryer Type on Biosolids PFAS Removal: A Suite of Full-Scale Analyses

John Norton Research Ending:

- Stay connected to each other
 - If we don't stay connected we cannot exchange ideas
- Stay indifferent until we have the data
- Stay curious
 - Novelty keeps life interesting

To stay ahead of the game...

Quote from Grandpa

- “Make your friends now, not when you need them”
- “Make your data now, not when you need them”

THANK YOU!

Patrick.mcnamara@marquette.edu
mcnamarap@bv.com