

Emerging Contaminants Update: Impacts, Sources, and Remediation Potential



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DuPage River & Salt Creek Workgroup Bimonthly Meeting | December 11, 2019

Contaminants of Emerging Concern

U.S. EPA Definition:

- Detected at low levels in surface water
- Concern about impacts on aquatic life
- No regulatory standards
- Recently 'discovered' due to updates or improvements in analysis or detection

Contaminants of Emerging Concern

- Includes several classes of substances
 - Persistent organic pollutants (POPs)
 - Legacy: PCBs, PAHs, DDT
 - Flame retardants (PBDEs)
 - Nonstick/stain repellent chemicals (PFASs)
 - Nanomaterials (Carbon nanotubes, TiO₂)
 - Microplastics and anthropogenic debris
 - Pharmaceuticals and personal care products (PPCPs)
 - Endocrine-disruptors (BPA)
- Can also include new sources of familiar substances
 - Coal tar sealcoat (PAHs)

PFAS

PFAS contamination is Michigan's biggest environmental crisis in 40 years

These once-common chemicals are linked to cancer and a host of other ailments. And they may be tainting more than 11,000 sites around Michigan.

Keith Matheny, Detroit Free Press
Updated 4:27 p.m. EDT Apr. 26, 2019

CHEMICALS

States take up PFAS fight: 'Is this the next asbestos?'

Ellen M. Gilmer and Ariana Figueroa, E&E News reporters • Published: Monday, June 3, 2019



FDA food testing finds contamination by PFAS and other 'forever chemicals'

Health Jun 3, 2019 12:33 PM EDT

The New York Times

E.P.A. Will Study Limits on Cancer-Linked Chemicals. Critics Say the Plan Delays Action.



By Coral Davenport

Feb. 14, 2019



NEWS ▾ SHOWS ▾ LIVE ▾

New study claims 43 states expose millions to dangerous chemical in drinking water

BY BRIAN PASCUS
MAY 7, 2019 / 3:48 PM /



LIVE RADIO

Shots

YOUR HEALTH

Scientists Dig Into Hard Questions About The Fluorinated Pollutants Known As PFAS



[BLOG] UNION OF CONCERNED SCIENTISTS

How the Chemical Industry Deployed the Disinformation Playbook on PFAS

GENNA REED, LEAD SCIENCE AND POLICY ANALYST | MARCH 27, 2019, 2:54 PM EDT

ATURES

sciencemag.org SCIENCE

622 17 MAY 2019 • VOL 364 ISSUE 6441

THEY PERSISTED

In Michigan, concerned citizens have helped reveal contamination by long-lasting nonstick chemicals

By Sara Talpos, in Rockford, Michigan



Toxic Chemicals Contaminate Cape

By Georeen Tanner

Published January 25, 2019

EPA plans to regulate cancer-causing chemicals found in America's drinking water

Ledyard King, USA TODAY Published 9:15 a.m. ET Feb. 14, 2019 | Updated 3:55 p.m. ET Feb. 14, 2019

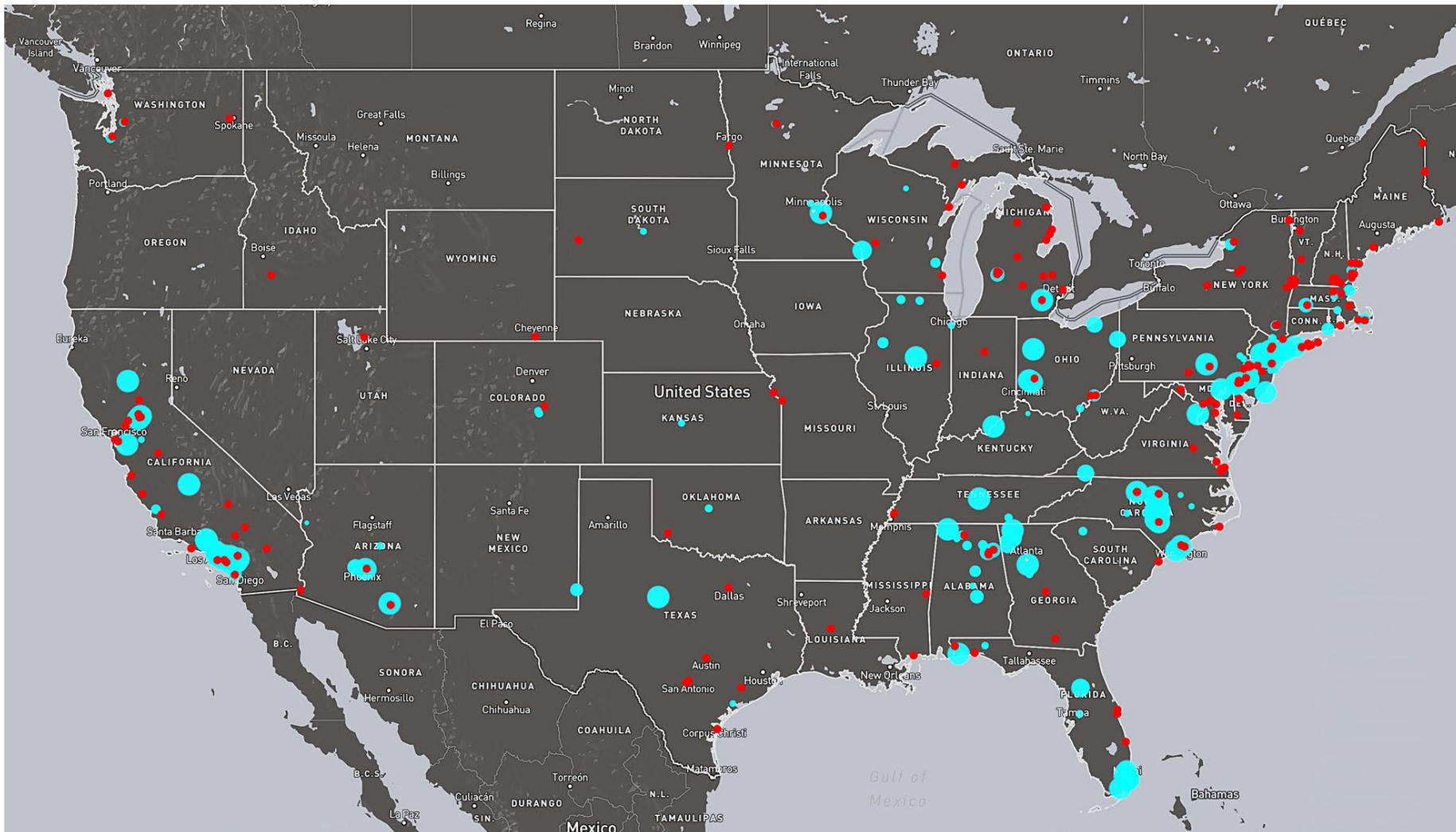
Toxic stream of 'mystery foam' near Detroit was PFAS – but from where?

Updated May 7, 2019;
Posted May 7, 2019

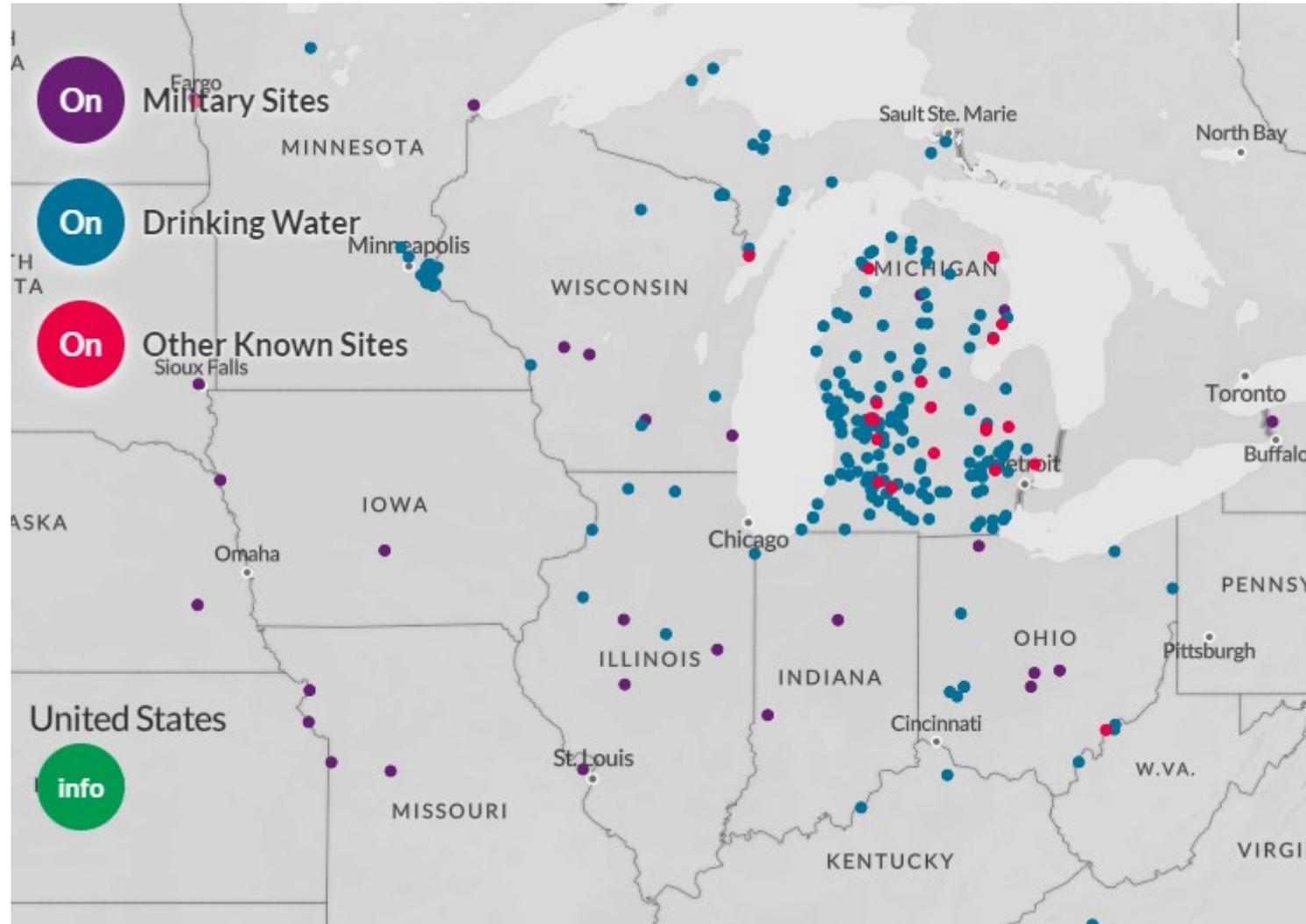


Michigar

PFAS Contamination in the US

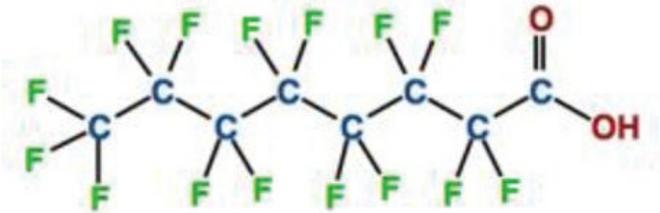


PFAS Contamination in the Midwest

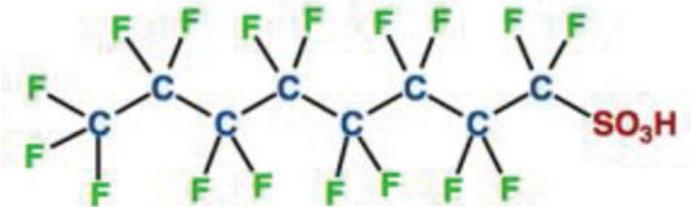


What are PFASs?

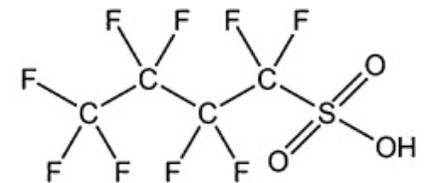
- Per- and poly-fluoroalkyl substances (PFAS)
- Represent a group of nearly 5,000 man-made organic compounds that mainly contain carbon-fluorine bonds
 - PFOA/PFAS = ≥ 6 fully fluorinated carbons
 - “long chain”
 - Alternatives (GenX, PFBS) = ≤ 5 fully fluorinated carbons
 - “short chain”
- Highly stable and persistent in the environment a.k.a. “forever” chemicals
- Bioaccumulate
- Resist heat, oil, grease, and water



PFOA - perfluorooctanoic acid



PFOS - perfluorooctanesulfonic acid



PFBS - perfluorobutanesulfonic acid

What products are PFAS in?

These compounds have been used in industrial applications and consumer products since the 1950s.

Aqueous Film Forming Foam (AFFF)

Non-stick cookware and utensils

Stain repellent carpets, upholstery, and other fabrics

Stain and water-repellant apparel (including Gore-Tex)

Grease/Oil-resistant food packaging and containers

Dental floss

Polishes, paints, sealants, and waxes

Cleaning products

Personal care products and cosmetics

Household dust/lint

Contaminated food



Per- and Polyfluoroalkyl Substances (PFAS)

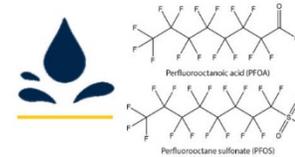
EXPOSURE



KEY FACTS

PFAS are man-made chemicals that **repel oil and water.**

PFOA and **PFOS** are the **most widely studied** forms of long-chain PFAS.



They are used in many **consumer products**



PFAS can get into the **environment** and **pollute water, soil, and air**

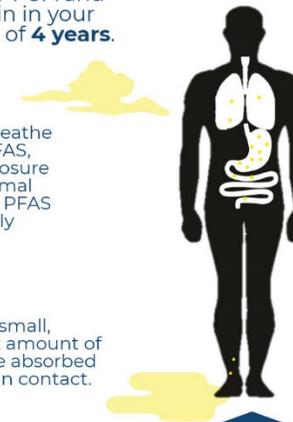


EXPOSURE

Once absorbed, PFOA and PFOS will remain in your body for upwards of **4 years**.

It is possible to breathe in vaporized PFAS, however this exposure route is of minimal concern because PFAS does not easily aerosolize.

A very small, insignificant amount of PFAS can be absorbed through skin contact.



The **most important** exposure route of concern is consumption of PFAS **contaminated water**.

PFAS is **readily absorbed** in the **gastrointestinal tract** and will quickly enter your bloodstream.

Some PFAS may be broken down, but PFOS and PFOA will **accumulate** in your body with continued exposure.

REDUCE EXPOSURE

Information from:
Agency for Toxic Substances
and Disease Registry

- Avoid or minimize drinking and cooking with PFAS contaminated water.
- Check fish advisories and avoid consuming fish from waters containing PFAS. Visit www.michigan.gov/eatsafefish for more information.
- Read consumer product labels and minimize use of products with non-stick, water-repellent, and stain-resistant properties.

How are we exposed to PFAS?

Per- and Polyfluoroalkyl Substances (PFAS)

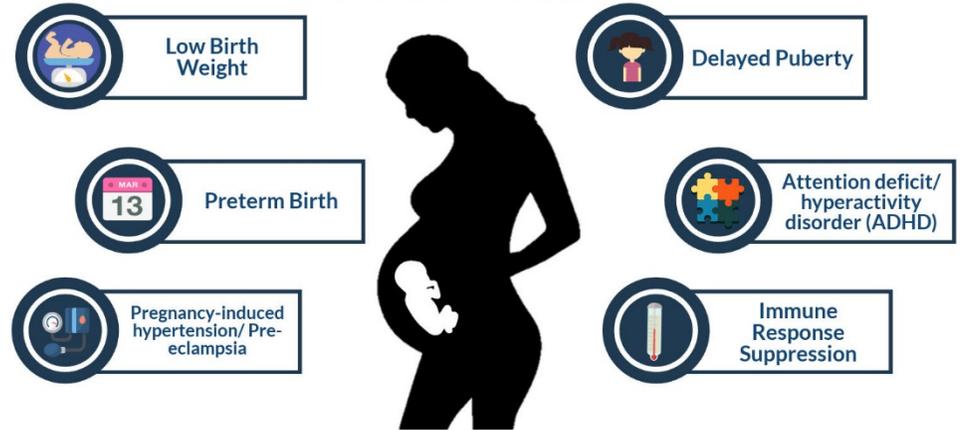
HEALTH EFFECTS



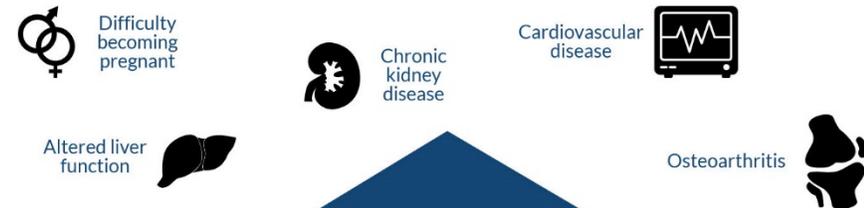
How are we exposed to PFAS?
What about health concerns?

Pregnant women, unborn fetus, and infants are most susceptible to adverse health effects once exposed to PFAS.

Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), two common forms of long-chain PFAS, have been associated with the following



Health effects that have been associated with exposure to PFAS in non-pregnant adults include:



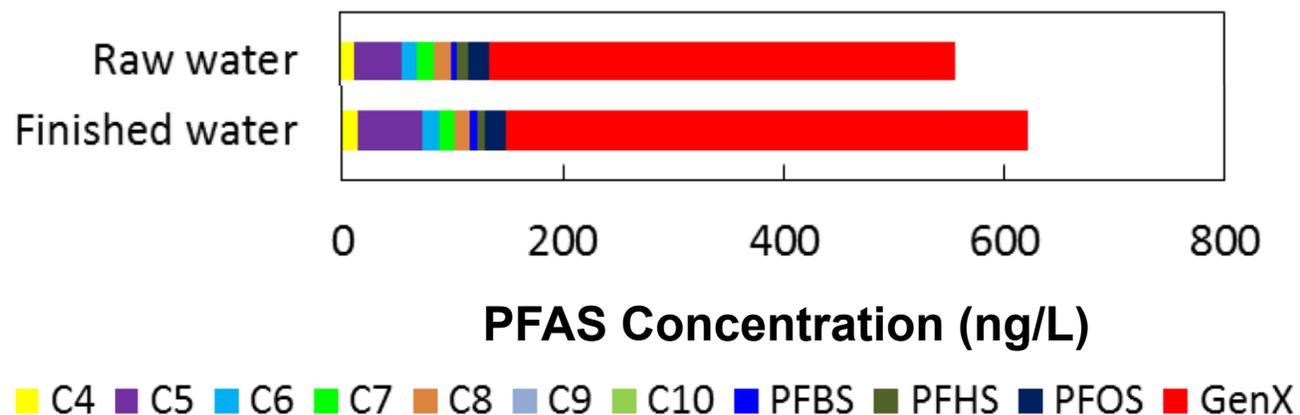
CANCER



- PFOA has been classified by the US EPA as "possibly carcinogenic to humans" [US EPA 2017]
- PFOA may cause prostate, testicular, bladder, liver, and/or kidney cancer [ATSDR 2018]

PFAS Removal

Conventional and advanced water treatments do not effectively remove legacy PFAS and GenX from drinking water



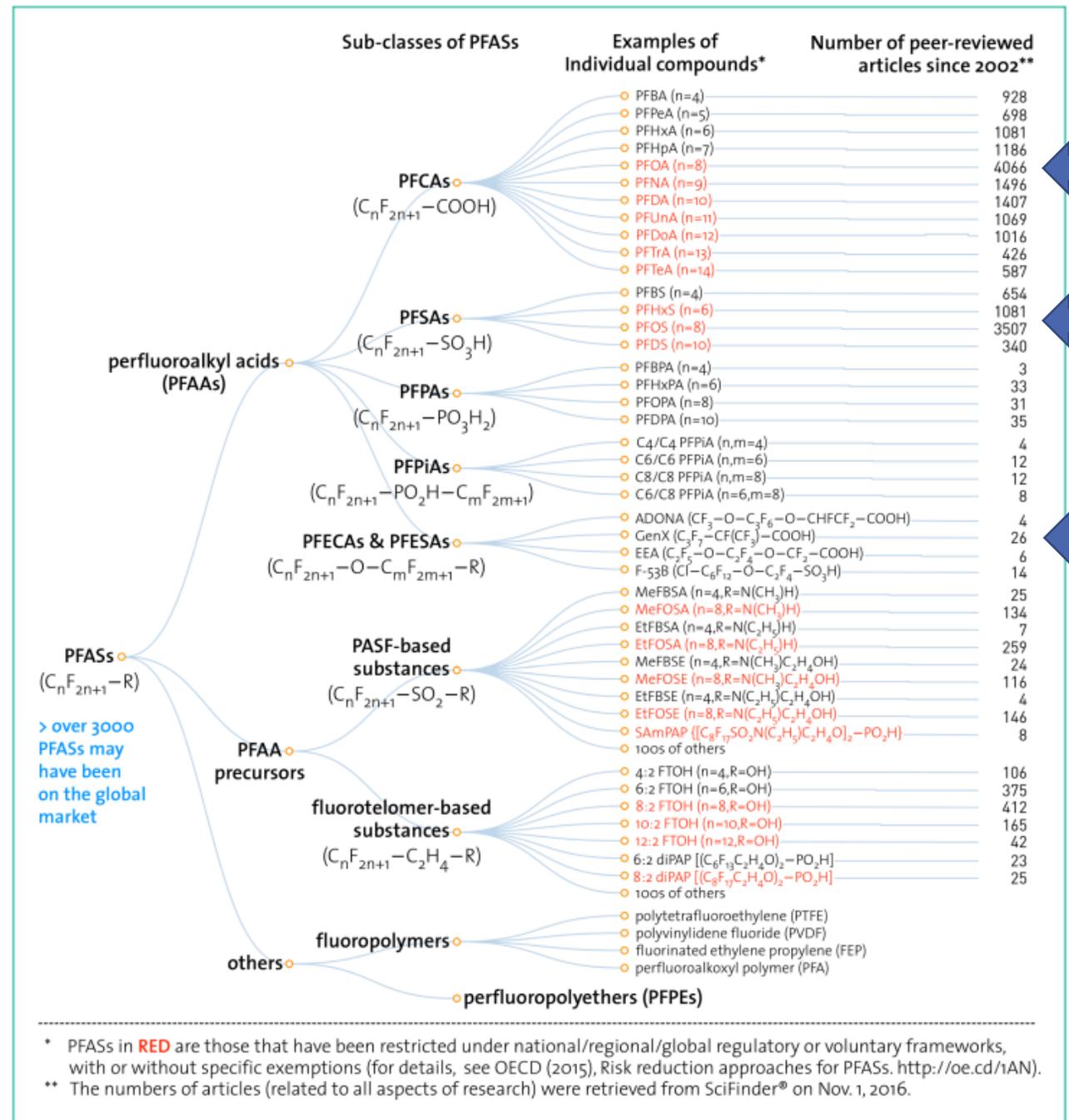
LC-MS-MS used for measurement

Treatment options include:

- Granular or powdered activated carbon
- Anion exchange
- Membrane filtration (RO)
- Advanced oxidation processes

Understanding Precursors

- 3,000+ different chemical varieties
- PFAS precursors (alcohols/amides) are less stable compounds that undergo transformation or degradation to PFAS
 - Can occur through biological and abiotic processes
 - Common analysis (EPA Method 537) does **not** evaluate precursors
- Precursors have different physical and chemical properties
 - Leads to different fate, transport behavior



PFAS Occurrence

- Found in soil, air, water, wildlife, and humans worldwide (including the Arctic and Antarctic)
 - 2015 study by U.S. National Health and Nutrition Examination Survey: PFAS found in over 97% of human blood samples
 - 2013-2015 Safe Drinking Water Act testing: PFAS found in 66 water supplies serving more than 16 million Americans in 33 states with at least one sample at or above EPA drinking water health advisories

The presence of PFAS was not widely reported until the late 1990s to early 2000s.

Timeline of PFAS Use

1947: 3M starts mass-manufacturing PFOA, one of the best-known members in a family of thousands of PFAS (per- and polyfluoroalkyl substances).

1951: DuPont starts using PFOA to make Teflon.

1953: Scotchguard is born when a similar compound to PFOA — a chemical called PFOS — found in lab to leave a coating that repels oil and water.

1960s: 3M and the U.S. Navy develop “aqueous film-forming foam” — AFFF — a firefighting foam containing PFOS and PFOA. Animal and human studies link the chemicals to liver damage.

1970s: Military sites, civilian airports and firefighting training centers start using AFFF worldwide. Research by 3M finds that the PFOA and PFOS are toxic.

1980s: A U.S. Navy study finds that AFFF has “adverse effects environmentally” and kills aquatic life. Research at 3M proves that employees have PFOA and PFOS in their blood. DuPont discovers that PFOA passes from a mother to her unborn baby via the umbilical cord.

1999: The EPA and 3M find that PFOS contamination is appearing at blood banks around the country. A farmer sues DuPont after scores of his cattle mysteriously die in Parkersburg, WV.

2000: 3M announces it will voluntarily halt production of PFOA and PFOS — technically known as “long-chain” chemicals — and will stop putting them in products by 2002. It starts creating new “short-chain” PFAS formulations such as GenX that scientists say are similarly hazardous.

2005: An EPA advisory panel concludes that PFOA is a “likely” human carcinogen.

2006: An EPA program encourages all major manufacturers to stop making long-chain PFAS, citing potential birth defects and other risks. DuPont and others agree to phase out production by 2015; like 3M, they start making new varieties, none proven safe.

2007: PFOS and PFOA are estimated to be in the blood serum of more than 98 percent of Americans.

2009: The EPA issues a nonenforceable “lifetime drinking water health advisory,” recommending a maximum of 200 parts per trillion for PFOS and 400 ppt for PFOA.

2011: The Department of Defense acknowledges the PFAS crisis in an internal study: hundreds of military sites are likely to have contaminated groundwater.

2012: The EPA directs large public water systems to test for PFAS. Results suggest that millions of Americans are exposed to PFAS in their drinking water.

2012: A landmark medical study finds a probable link between PFOA exposure and six diseases including some types of cancers.

2016: The EPA issues a far stricter *lifetime health advisory level* for PFOA and PFOS in drinking water: **70 parts per trillion**.

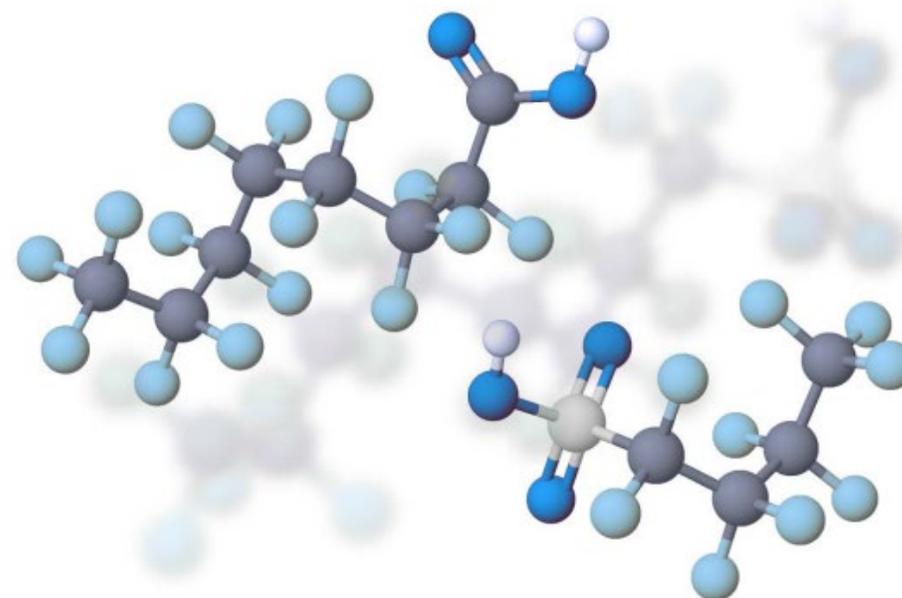
March 2018: The Pentagon reports that PFAS contamination is detected at 121 military sites and suspected at hundreds of others. PFAS levels exceed the EPA's health advisory in at least 500 drinking-water supplies in nearby communities have.

November 2018: EPA releases new tools to test additional PFAS, including GenX, in drinking water.

February 2019: EPA's PFAS Action Plan outlines concrete steps the agency is taking to address PFAS and to protect public health over the next several years. Anticipated actions in 2019 include setting the maximum contaminant level (MCL) for drinking water.

February 14, 2019:
EPA published the
PFAS Action Plan

EPA's Per- and Polyfluoroalkyl Substances (PFAS) Action Plan



EPA ACTION PLAN ON PFAS

ISSUE

ACTION

TIMEFRAME

Priority Actions

Long-Term Actions

DRINKING WATER

Develop a national drinking water regulatory determination for PFOA/PFOS

2019

ACCOUNTABILITY

List PFOA/PFOS as a hazardous substances under the Comprehensive Environmental Response, and Compensation, Liability Act (CERCLA)

Ongoing; Started in 2018

GROUNDWATER

Develop Interim Cleanup Recommendations for PFOA/PFOS

Draft interim guidance available for comment through June 10

TOXICITY

Finalize draft toxicity assessments for GenX and PFBS; other short-chain toxicity information coming in 2020

Reviewing comments

ANALYTICAL METHODS & ANALYZING OTHER MEDIA

Expand current drinking water method 537 in include GenX; develop new testing methods for short-chain PFAS

Completed Method 537.1 in 2018; additional methods coming 2019

Develop and validate methods for other metrics (wastewater, surface water, groundwater, soil, sediment, biosolids, fish tissue, ambient air, state emissions, off-gases)

Ongoing 2019-2021

EXPAND KNOWLEDGE

Use new statutory requirements added by Frank L. Lautenberg Chemical Safety for the 21st Century Act to review new PFAS and issue significant new use rules (SNURs)

Ongoing; started in 2016

REPORTING

Explore listing PFAS chemicals on Toxic Release Inventory

Start 2019

WATER QUALITY

Determine if available data and research support the development of CWA Section 304(a) ambient water quality criteria for human health for PFAS

2021

EFFLUENT LIMITATIONS

Explore and identify industrial sources that may warrant regulation through national ELGs for the ELG 14

Start 2019

MONITORING

Under next unregulated contaminant monitoring rule (UCMR), utilize newer methods available for PFAS detection and at lower minimum reporting levels (MRLs)

2020

ATMOSPHERIC

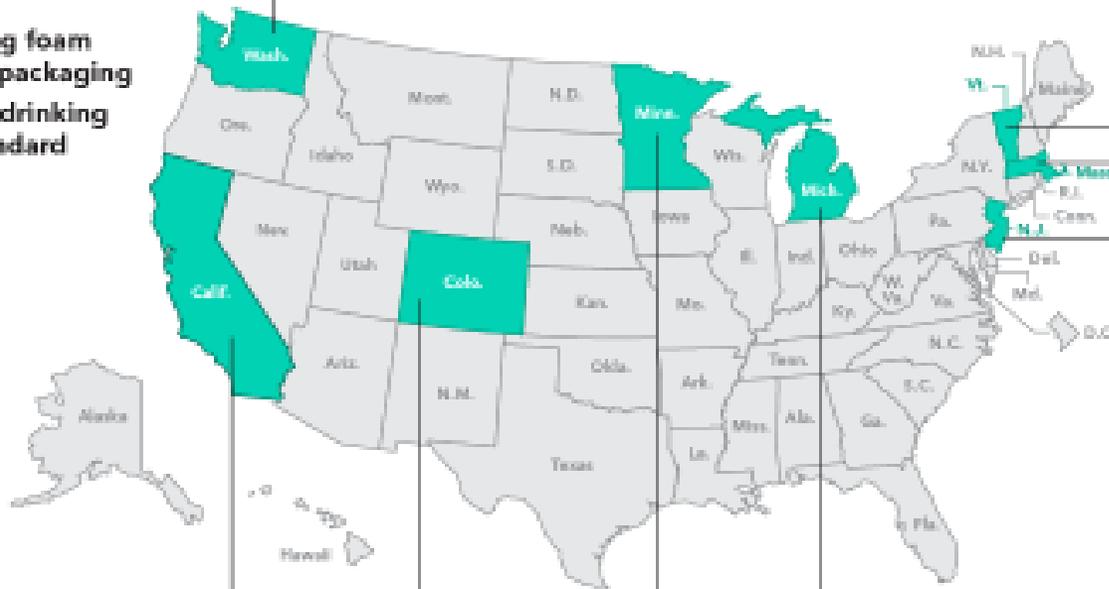
Incorporate PFAS into EPA atmospheric models to understand atmospheric fate and transport

2022

States With Numerical PFAS Limits

Washington

- Banned in firefighting foam and food packaging
- Proposed drinking water standard



Vermont

- 20 PPT (PFAS)
- Drinking water health advisory for 6 PFAS

Massachusetts

- 70 PPT (PFAS)
- State guidance for concentrations of 6 PFAS in drinking water

New Jersey

- Set PFNA standard at 13 ppt
- Weighing proposed standards for:
PFOA at 14 ppt
PFOS at 13 ppt

California

- 14 PPT (PFOA)
- 13 PPT (PFOS)
- Drinking water notification guidance

Colorado

- PFOA/PFAS listed as hazardous waste
- 70 PPT (Combined PFOA/PFOS)
- Groundwater quality standard for El Paso County only

Minnesota

- 36 PPT (PFOA)
- 27 PPT (PFOS)
- Health-based guidance values

Michigan

- 70 PPT (Combined PFOA/PFOS)
- State standard for concentrations in drinking water

Microplastics

Primary production
8300

Million Metric Tons

In-use stocks
2500 primary (30%)

Discarded
4900



4600
(55%)

700
(8%)

300

Incinerated

10% of the plastic produced each year enters aquatic habitats

Recycled
600 (7%)

~92% of the plastic that was ever produced still exists...
somewhere, in some form





Accumulation



Litter in aquatic environments has several fates



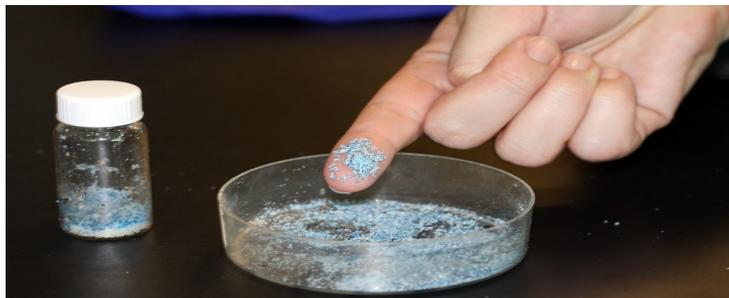
Ingestion



Breakdown & Decomposition

Microplastic Sources

- Breakdown from larger litter
- Terrestrial runoff
- Domestic waste water
 - Fibers from clothing
 - Incomplete treatment removal
 - 75-99% removed (Conley et al. 2019)
- Personal care products
- Rivers to downstream ecosystems



Types of Microplastics

1° - Production pellets



www.frbiz.com



www.alibaba.com

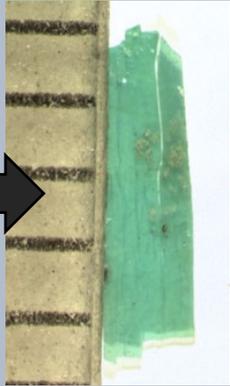
2° - Fragments, foam, film



archipelago.gr



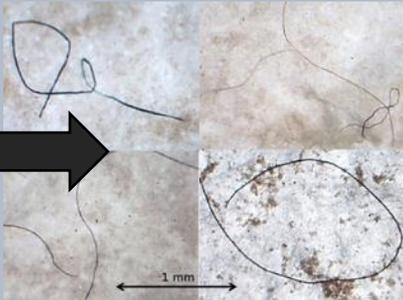
kasitindustry.com



1° - Microbeads

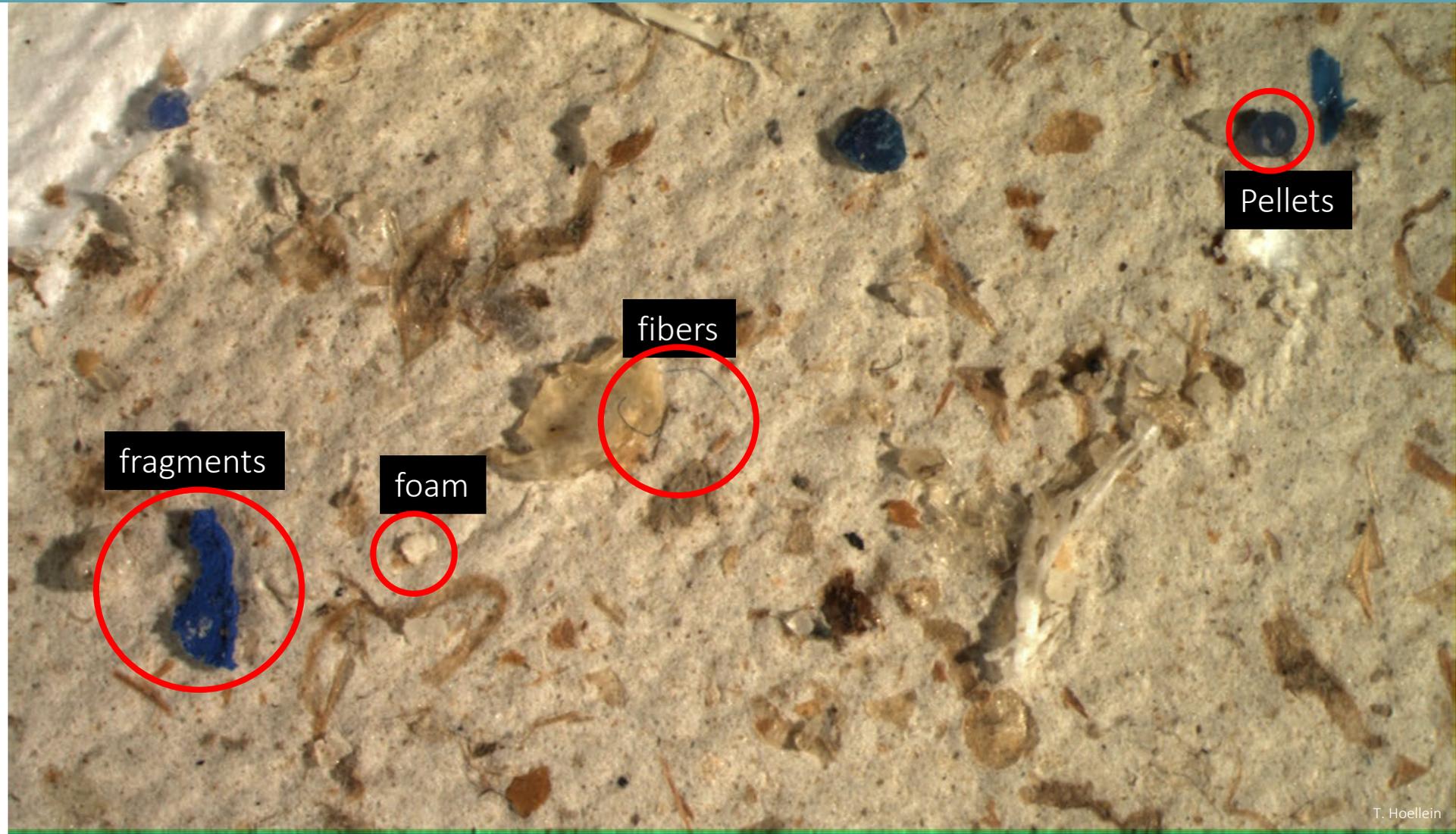


2° - Synthetic fibers



<http://workjournal.archipelago.gr/tag/microplastics/>

Types of Microplastics



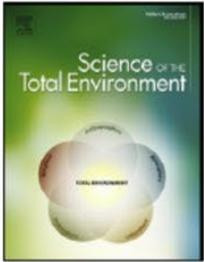
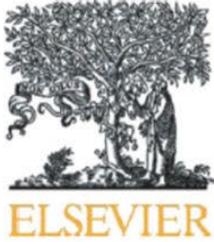
Ecological Effects of Microplastics: IISG Meta-Analysis

Science of the Total Environment 631–632 (2018) 550–559

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv



Review

A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates

Carolyn J. Foley ^{a,b,*}, Zachary S. Feiner ^a, Timothy D. Malinich ^a, Tomas O. Höök ^{a,b}

^a Purdue University, Department of Forestry and Natural Resources, 195 Marsteller St., West Lafayette, Indiana 47907, USA

^b Illinois-Indiana Sea Grant College Program, 195 Marsteller St., West Lafayette, Indiana 47907, USA



IISG Meta-Analysis

Examined 43 published studies

In order to be included, study must have:

- Measured at least one effect of direct exposure to an organism
- Been an experiment
- Included a 'no microplastics' control
- Reported mean, sample size, and variance measures

For aquatic organisms, what is the impact of
exposure to microplastics on:

consumption and feeding?

growth?

reproduction?

survival rates?

IISG Meta-Analysis

- Effect varied with taxonomic group

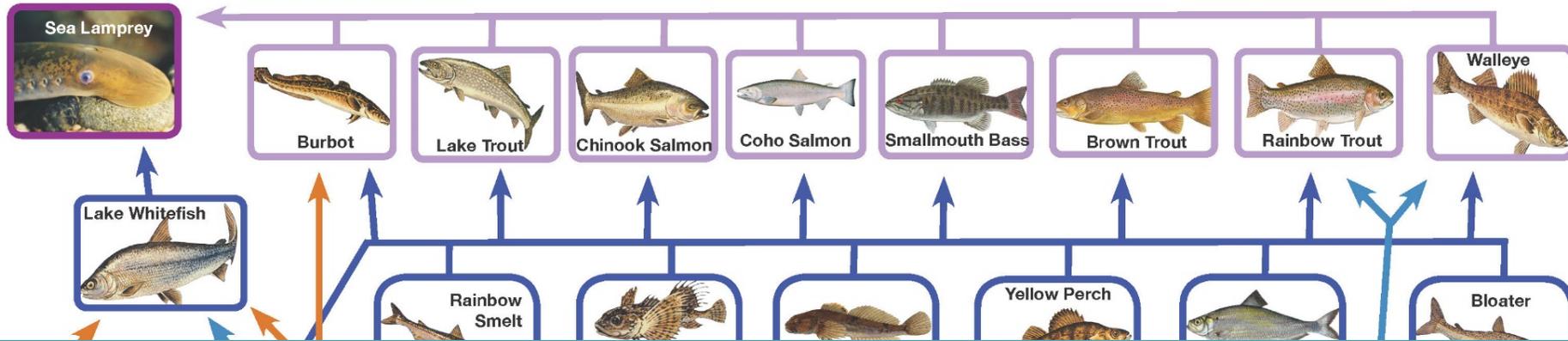
| | Consumption | Growth | Reproduction | Survival |
|------------------------|-------------|--------|--------------|----------|
| Zooplankton | | * | * | * |
| Echinodermata | | | + | |
| Molluscs | + | + | | |
| Macroinvertebrates | | + | | |
| Larval & Juvenile Fish | * | | | + |
| Adult Fish | | | | |

* = significant negative effects

+ = possible negative effects

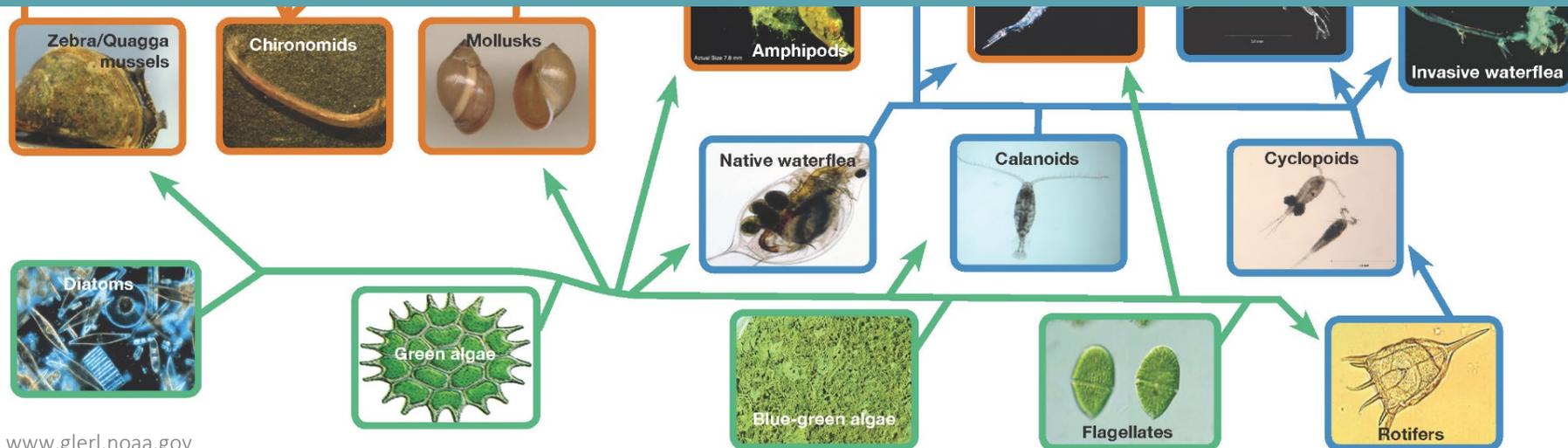


Lake Michigan Food Web



What do these results mean?

Many aquatic biota may be affected, but no 'slam dunks.'
Zooplankton most susceptible to microplastics exposure.



Ecological Effects of Microplastics: Impacts to humans?

Microplastics have been found in:

Sea salt (Kim et al. 2018)

Chicken gizzards (Lwanga et al. 2017)

Honey (Liebezeit and Liebezeit 2013)

Drinking water (bottled and tap) (WHO 2014)

Seafood & shellfish (Van Cauwenberghe and Janssen 2014)

Beer (Kosuth et al. 2018)

Humans consume up to 52,000 microplastic particles/year; increases to 121,000 particles/year when inhalation is considered

Those who only consume bottled water are consuming an additional 90,000 plastics/year (4,000 for tap)



How do v

Legislativ

Consumer-driven or g

Straw Bans

- Chicago non-binding s
- No statewide straw ba

Plastic Bag Bans

- Chicago bag tax (2017
- No statewide bag tax

Single-use plastic bans

- France banned plastic (2019), plastic bags (Ju



oplastics?

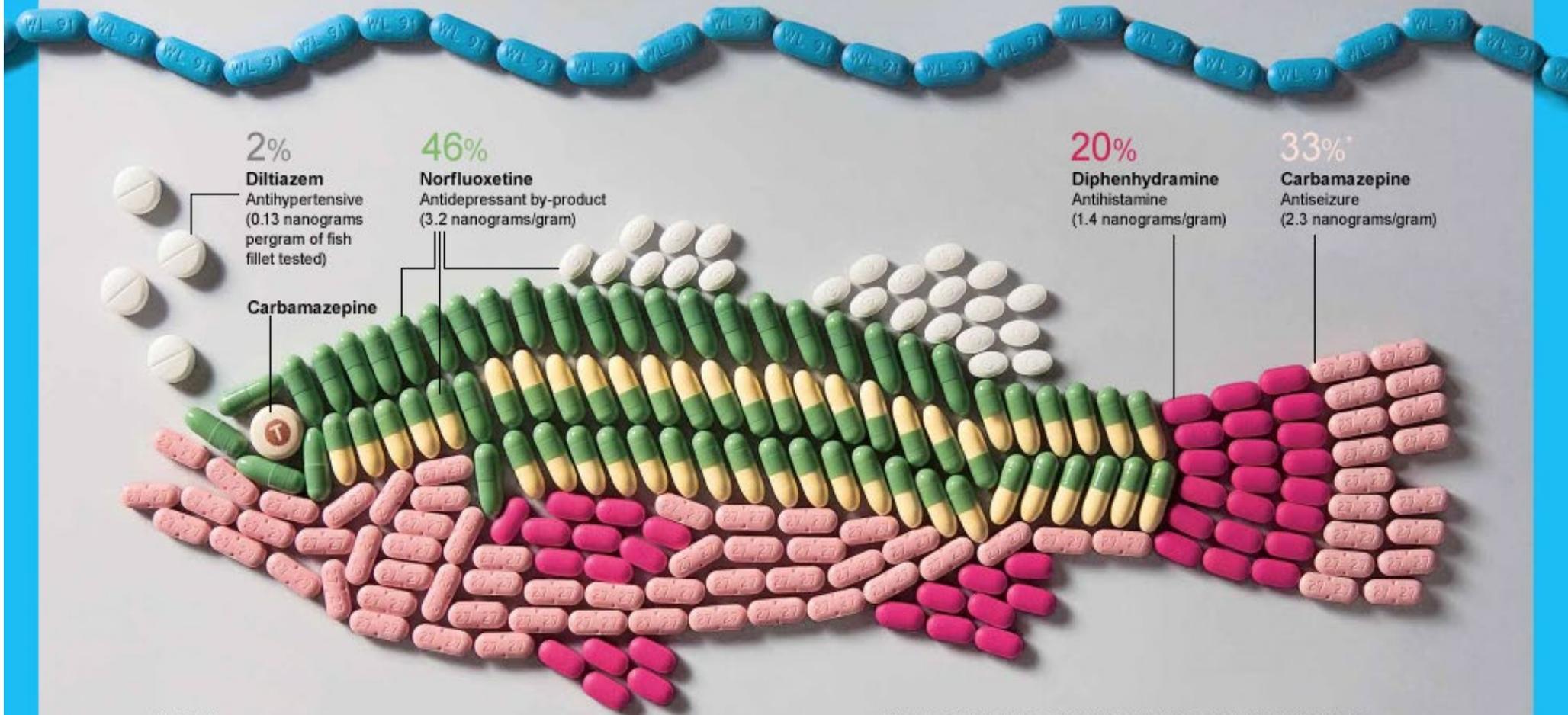


How do we solve a problem like microfibers?

Engineering Solutions:
Consumer-Driven or Municipal Responsibility?



PPCPs



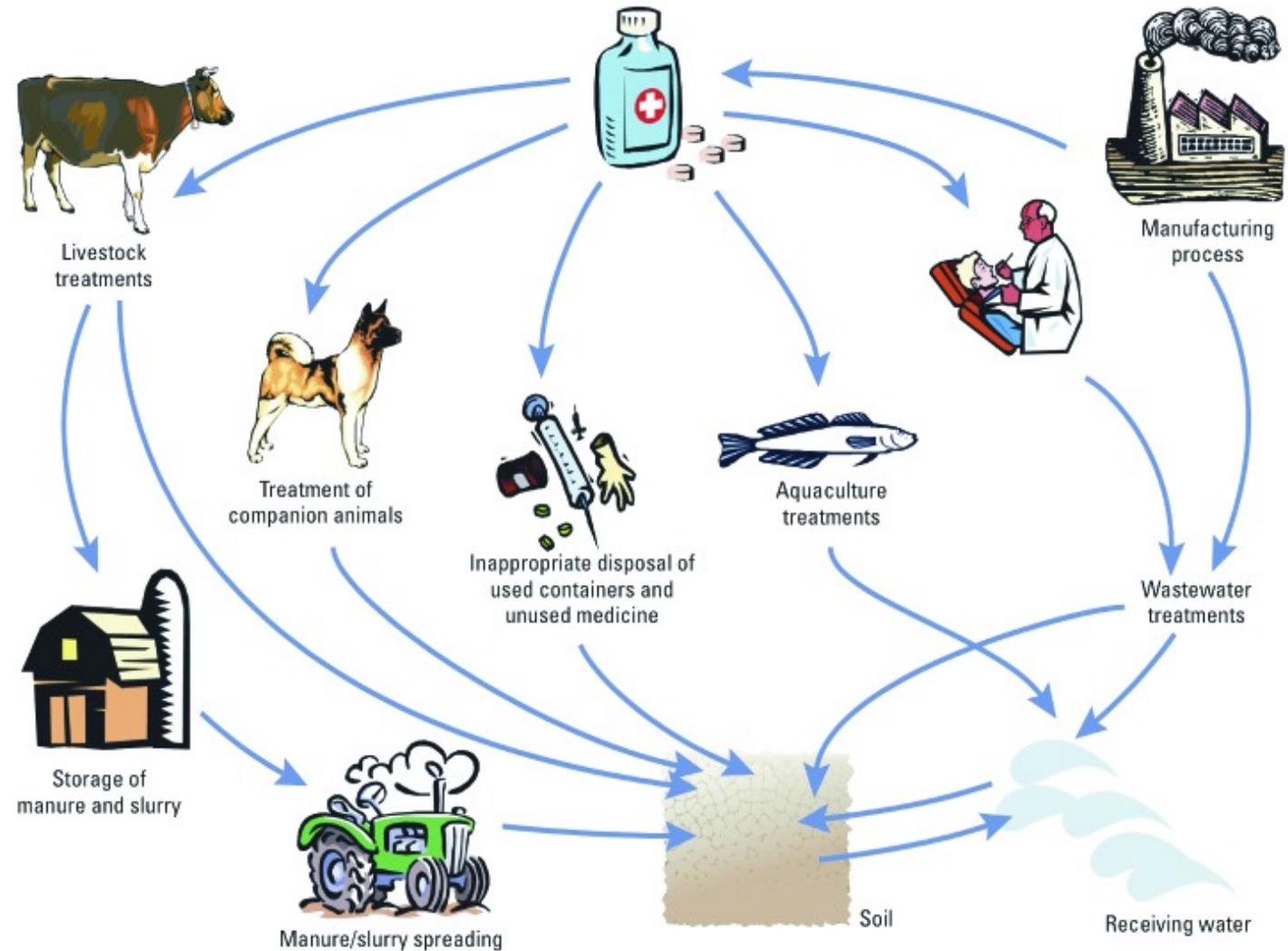
Fish Pharm
 These pills represent the relative amounts of four pharmaceutical drugs found in fish pulled from Chicago's North Shore Channel and tested by Baylor scientists.

The traditional foe of water quality is waste from factories and farms, but now environmental regulators are eyeing a new pollution source: our medicine chests. Fish caught downstream from sewage treatment plants in five U.S. cities contained traces of pharmaceuticals and toiletries, Baylor University researchers found in a recent study. You'd have to eat tons of fish for such small concentrations to affect human health, but the products could pose a threat to marine life. To assess the risk, the EPA has expanded monitoring to 150 sites, with results due in 2011.

* PERCENTAGES EXCEED 100 BECAUSE OF ROUNDING.
 BLUE ANTIHISTAMINE PILLS (TOP) ARE NOT INCLUDED IN PERCENTAGES.

How do PPCPs reach the environment?

- Effluent from wastewater treatment plants (WWTPs)
- Surface application of manure and biosolids
- Commercial animal feeding operations and aquaculture
- Landfill leachate (direct and wastewater treatment)
- Septic systems



What problems do PPCPs cause?



Aquatic wildlife

Reproductive and developmental impairments



Terrestrial wildlife

Fatalities in non-target species



Agricultural crops

Uptake into plants consumed by people



Livestock

Potential to promote antibiotic resistance

PPCPs with Environmental Impacts: Antidepressants

African clawed frog (*Xenopus laevis*) tadpoles were raised in clean water and in tanks of water mixed with 38 ppb fluoxetine (Prozac)

At 57 days the control group had begun to develop legs, but the exposed tadpoles had delayed metamorphosis.



Control group



38 ppb FL

What public health problems can PPCPs cause?



Accidental poisonings

Children do not always know the difference between medicine and candy.



Drug abuse

Many teenagers believe prescription medications are safer than “street drugs.”



Drug misuse

The elderly can become confused about proper use when they take multiple medications.



Pet poisonings

Pets sometimes cannot resist the temptation to eat what they find in the trash.

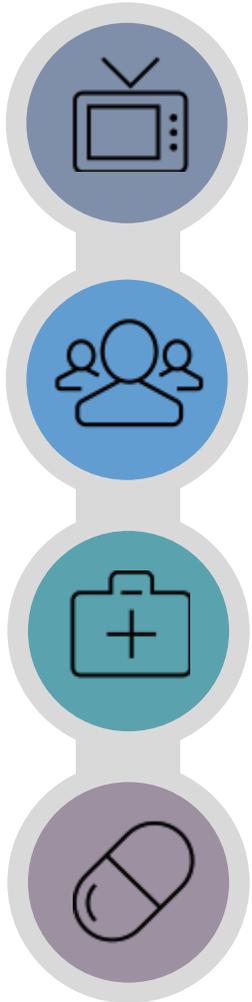
Potential Impacts for People:

Do I need to be worried about my drinking water?

- Chemicals found in the environment are several orders of magnitude lower than dosage-level concentrations
- Adverse health effects from PPCPs in drinking water are NOT expected (WHO 2011)
- Can try to predict long-term impacts by using animals as sentinels, but the long-term effects on humans are largely unknown



Reducing Impacts for People: IISG's Unwanted Meds Program



- 60+ outreach and medicine collection events
- 7,500+ people educated; 650,000+ page views on unwantedmeds.org
- 800+ veterinary professionals educated from across the country
- 118+ tons of medicine collected



What's next?

Addressing CECs requires focus in 4 areas

1. New research

- Prioritize compounds of greatest importance
- Evaluate exposures and impacts on people and ecosystems
- Evaluate new treatment techniques

2. New treatment technologies

- Evaluate new techniques
- Update existing wastewater technologies

3. Behavioral changes in the marketplace

- Better labeling and promotion of safe alternatives
- Personal responsibility in consumer choices

4. Policy reforms

- Shift burden of proof (EU model = prove safety)
- More effective risk assessment procedures to support regulation



ILLINOIS-INDIANA SEA GRANT

**POLLUTION
PREVENTION
PROGRAM**

Questions?

Thank you!

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www.iiseagrant.org | www.unwantedmeds.org

DuPage River & Salt Creek Workgroup Bimonthly Meeting
December 11, 2019