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science for a changing world

USGS science to understand environmental contaminants and pathogens of emerging concern

Geoff Plumlee
Chief Scientist (designate)
Associate Director, Environmental Health
gplumlee@usgs.gov

Mike Focazio
Environmental Health Integrated Programs Coordinator
mfocazio@usgs.gov

U.S. Department of the Interior
U.S. Geological Survey

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USGS environmental health science

- We develop and apply advanced analytical, laboratory, field, and modeling methods to understand, measure, monitor, map, and anticipate what are **actual versus perceived** health risks posed by contaminants and pathogens in the environment.
  - Sources (natural and human), transport, and fate in the subsurface and the surface environment
  - Environmental backgrounds and baselines
  - Exposures to and health effects on insects, fish, wildlife
  - Exposures to humans and (*in collaboration with human health scientists*) human health implications

Environmental contaminants and pathogens of emerging concern

- Many have been known about for years, but are currently receiving increased concern about their health and environmental effects.

Toxins produced by harmful algal blooms

Perfluoroalkyl compounds

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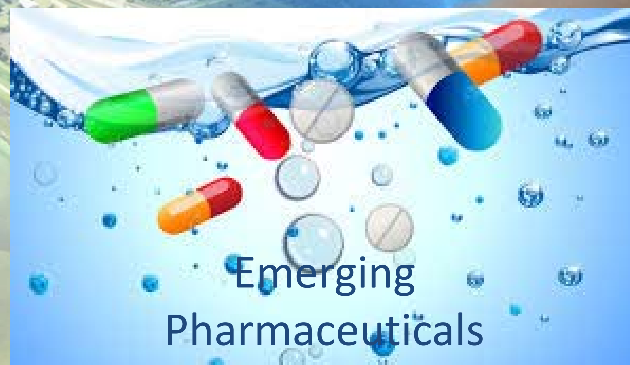
Environmental contaminants and pathogens of emerging concern

- Others are relatively recently recognized

Emerging Pesticides



Emerging Pharmaceuticals

Emerging pathogens
e.g., Avian Influenza Virus

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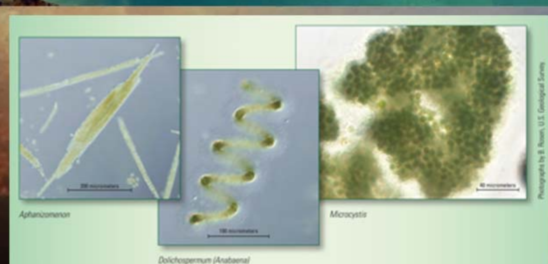
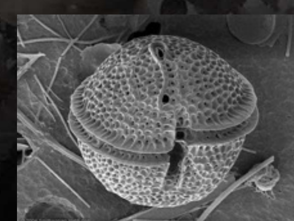
Cyanobacterial and other toxins produced by harmful algal blooms





What puts the "H" into "HABs"?

- Algal blooms can deprive aquatic organisms of oxygen
- Algal blooms can (but do not always) release toxins into lakes, streams, and seawater.
- Exposures to high levels of algal toxins in drinking waters, recreational waters, and seafood during blooms have caused toxicity and mortalities in fish, other aquatic organisms, livestock, and pets
- There is also speculation that chronic exposures to low levels of algal toxins in drinking waters, seafood, and desert dusts can lead to other diseases in humans
- However, not all algal blooms are harmful, and not all harmful blooms are toxic


Environmental Health NEWS

HEALTH

Are Algae Blooms Linked to Lou Gehrig's Disease?

Medical researchers are now uncovering clues that appear to link some cases of ALS to people's proximity to lakes and coastal waters

SCIENTIFIC AMERICAN


Amyotrophic Lateral Sclerosis, 2009; (Supplement 2): 109–117

informa healthcare

Cyanobacteria and BMAA exposure from desert dust: A possible link to sporadic ALS among Gulf War veterans

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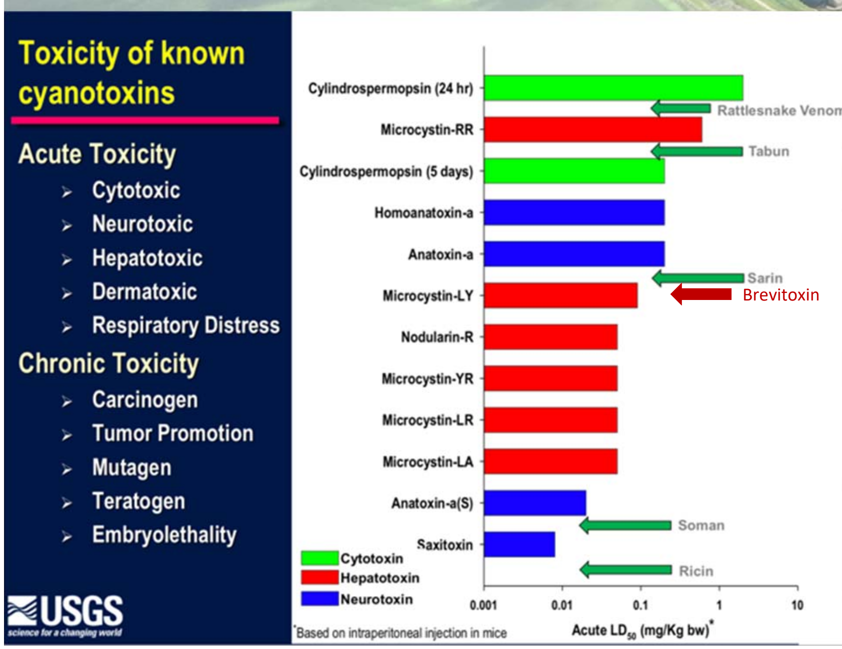
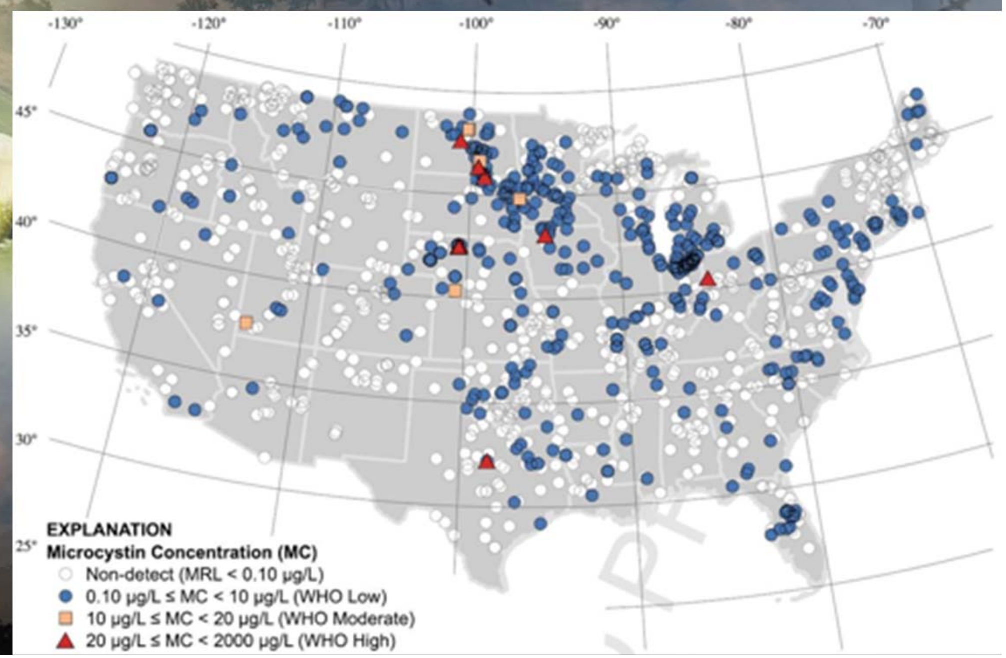
USGS algal toxin science

- Analytical methods
- Source microorganisms, when/why they produce toxins
- Occurrence (waters, sediments, dusts, animals), transport, transformations, environmental persistence
- Exposure pathways to and uptake by humans and other organisms
- Concentrations, distribution, toxicity effects in fish, wildlife, domestic animals
- Human health implications

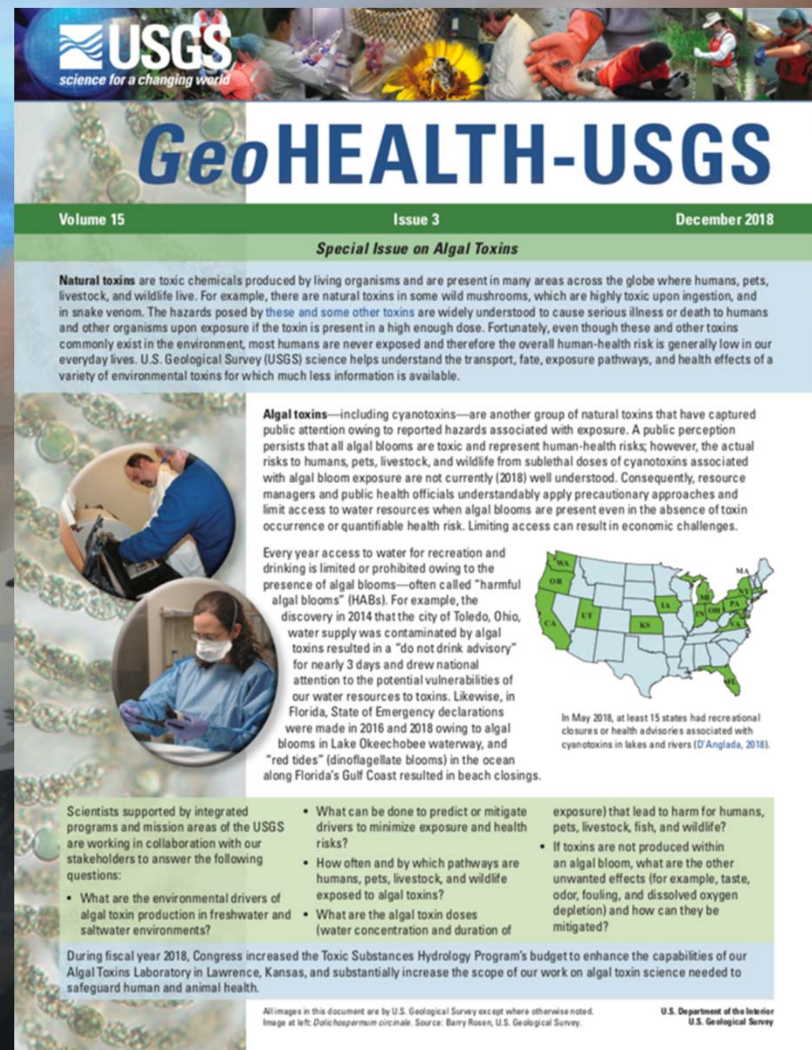




USGS algal toxin science

Keith Loftin, Jennifer Graham, many others

See most recent issue of GeoHEALTH-USGS Newsletter: https://www2.usgs.gov/envirohealth/geohealth/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GeoHEALTH-USGS

Volume 15 | Issue 3 | December 2018

Special Issue on Algal Toxins

Natural toxins are toxic chemicals produced by living organisms and are present in many areas across the globe where humans, pets, livestock, and wildlife live. For example, there are natural toxins in some wild mushrooms, which are highly toxic upon ingestion, and in snake venom. The hazards posed by these and some other toxins are widely understood to cause serious illness or death to humans and other organisms upon exposure if the toxin is present in a high enough dose. Fortunately, even though these and other toxins commonly exist in the environment, most humans are never exposed and therefore the overall human-health risk is generally low in our everyday lives. U.S. Geological Survey (USGS) science helps understand the transport, fate, exposure pathways, and health effects of a variety of environmental toxins for which much less information is available.

Algal toxins—including cyanotoxins—are another group of natural toxins that have captured public attention owing to reported hazards associated with exposure. A public perception persists that all algal blooms are toxic and represent human-health risks; however, the actual risks to humans, pets, livestock, and wildlife from sublethal doses of cyanotoxins associated with algal bloom exposure are not currently (2018) well understood. Consequently, resource managers and public health officials understandably apply precautionary approaches and limit access to water resources when algal blooms are present even in the absence of toxin occurrence or quantifiable health risk. Limiting access can result in economic challenges.

Every year access to water for recreation and drinking is limited or prohibited owing to the presence of algal blooms—often called "harmful algal blooms" (HABs). For example, the discovery in 2014 that the city of Toledo, Ohio, water supply was contaminated by algal toxins resulted in a "do not drink advisory" for nearly 3 days and drew national attention to the potential vulnerabilities of our water resources to toxins. Likewise, in Florida, State of Emergency declarations were made in 2016 and 2018 owing to algal blooms in Lake Okeechobee waterway, and "red tides" (dinoflagellate blooms) in the ocean along Florida's Gulf Coast resulted in beach closings.

In May 2018, at least 15 states had recreational closures or health advisories associated with cyanotoxins in lakes and rivers (D'Anglada, 2018).

Scientists supported by integrated programs and mission areas of the USGS are working in collaboration with our stakeholders to answer the following questions:

- What are the environmental drivers of algal toxin production in freshwater and saltwater environments?
- What can be done to predict or mitigate drivers to minimize exposure and health risks?
- How often and by which pathways are humans, pets, livestock, and wildlife exposed to algal toxins?
- What are the algal toxin doses (water concentration and duration of exposure) that lead to harm for humans, pets, livestock, fish, and wildlife?
- If toxins are not produced within an algal bloom, what are the other unwanted effects (for example, taste, odor, fouling, and dissolved oxygen depletion) and how can they be mitigated?

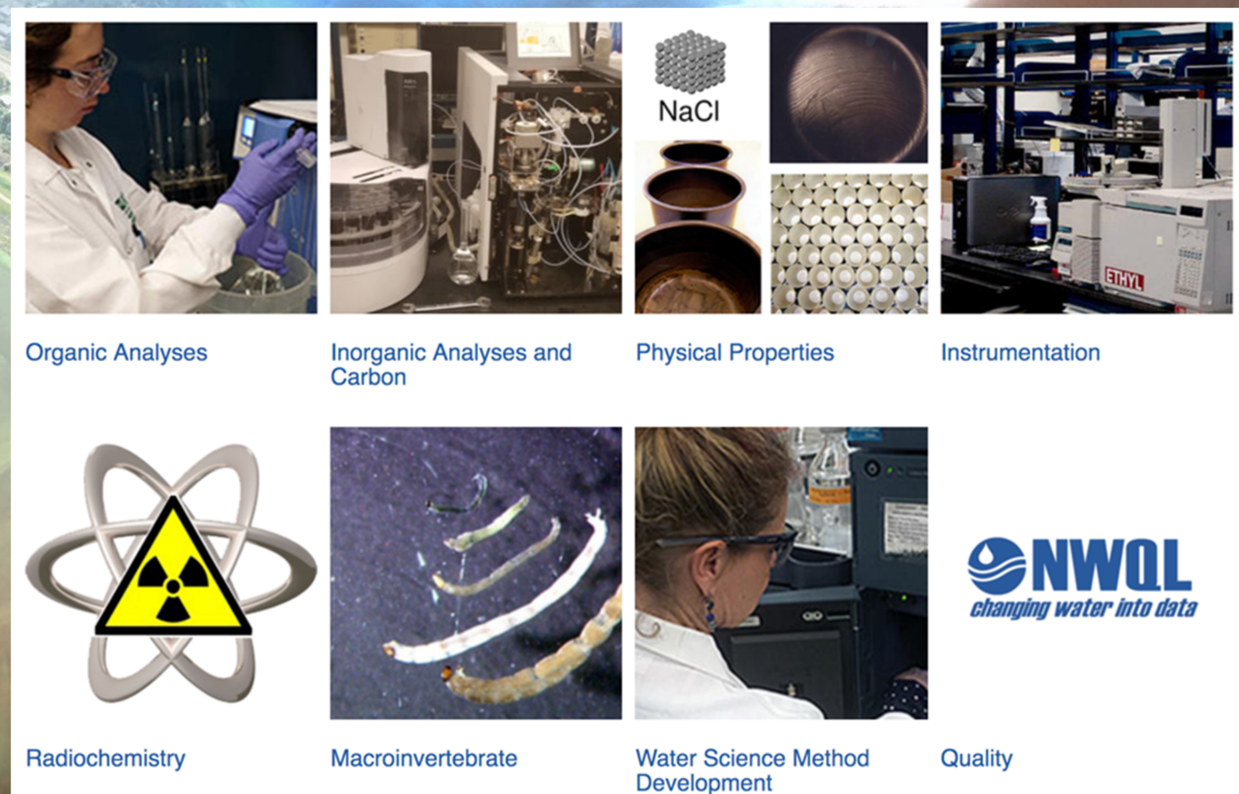
During fiscal year 2018, Congress increased the Toxic Substances Hydrology Program's budget to enhance the capabilities of our Algal Toxins Laboratory in Lawrence, Kansas, and substantially increase the scope of our work on algal toxin science needed to safeguard human and animal health.

All images in this document are by U.S. Geological Survey except where otherwise noted.
Image at left: *Dolichospermum circinale*. Source: Barry Rosen, U.S. Geological Survey.

U.S. Department of the Interior
U.S. Geological Survey

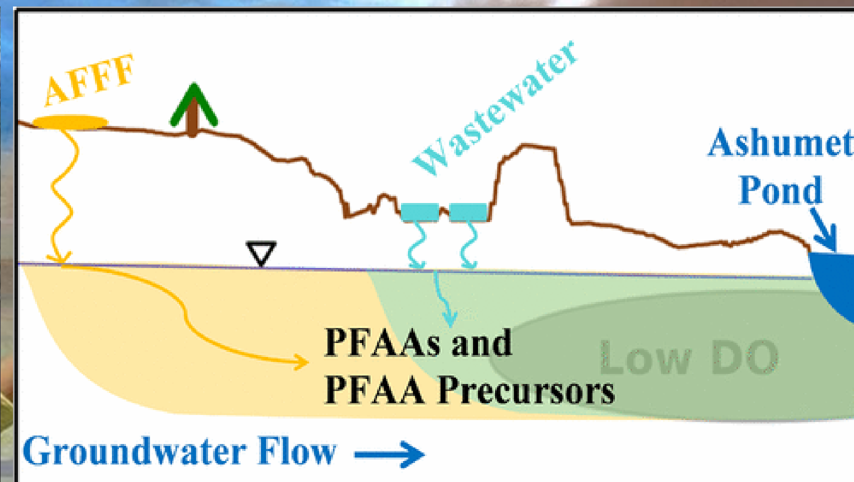
Poly- and Perfluoroalkyl (PFAS) compounds

- 4000+ compounds
- Challenges in sampling, preservation, and analysis
- Analytical methods development by USGS National Water Quality Laboratory (NWQL)
  - Validating a new liquid chromatography / tandem mass spectrometry (LC/MS/MS) analytical method for trace quantitative analysis of 34 PFAS compounds in water.



Poly- and Perfluoroalkyl (PFAS) compounds

- Can persist for decades in groundwater systems



Firefighting foam and remediation wastewaters, Joint Base Cape Cod

Weber, A.K., Barber, L.B., LeBlanc, D.R., Sunderland, E.M., and Vecitis, C.D., 2017, Geochemical and hydrologic factors controlling subsurface transport of poly- and perfluoroalkyl substances, Cape Cod, Massachusetts: Environmental Science and Technology, doi:10.1021/acs.est.6b05573.

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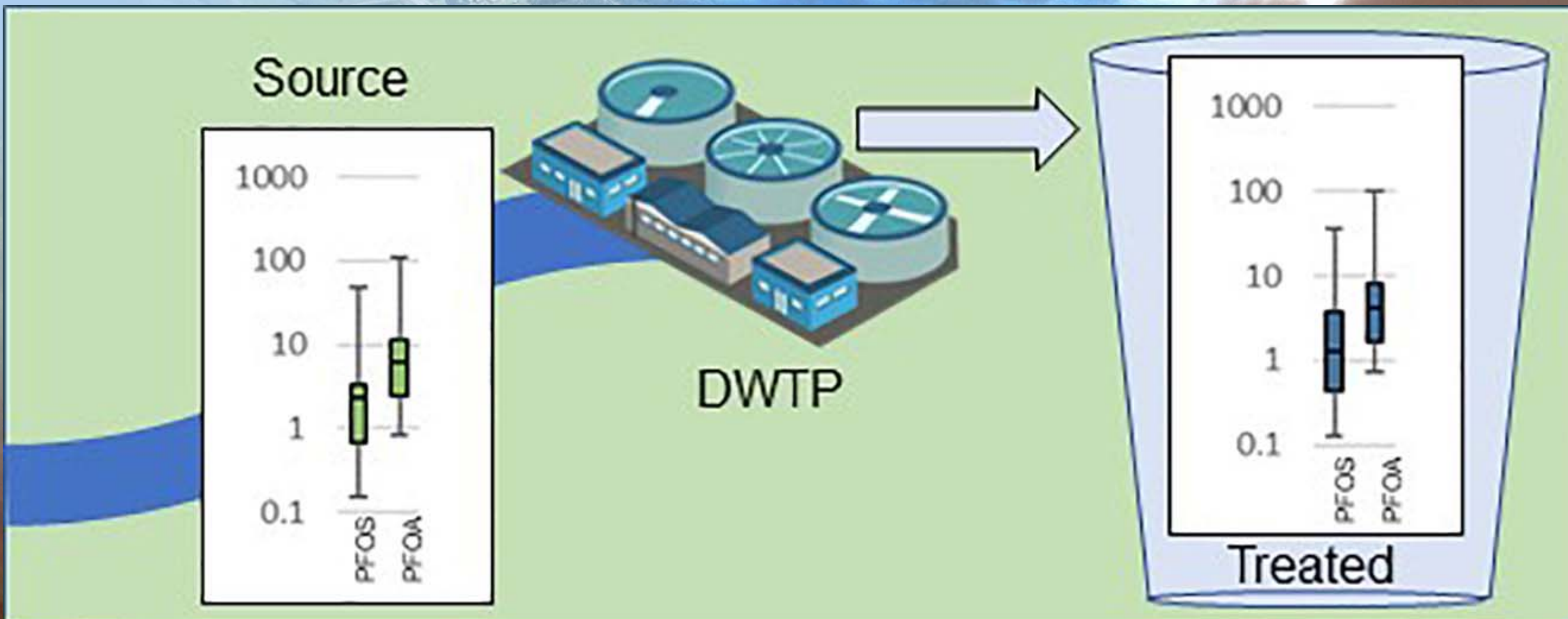
Poly- and Perfluoroalkyl (PFAS) compounds

- Can persist through drinking water treatment



Dana Kolpin, Ed Furlong, and colleagues.
Boone et al., 2019, Per- and polyfluoroalkyl substances in source and treated drinking waters of the United States, STOTEN, v. 653, 359-369.

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Poly- and Perfluoroalkyl (PFAS) compounds

Tree swallows, photo by Keith Williams, USGS

Tree swallows, Clarks Marsh, former Wurtsmith AFB, Oscoda, Michigan

- High uptake of highly refined PFAS compounds was not found to translate into adverse reproductive, physiological effects
- Custer et al., 2019

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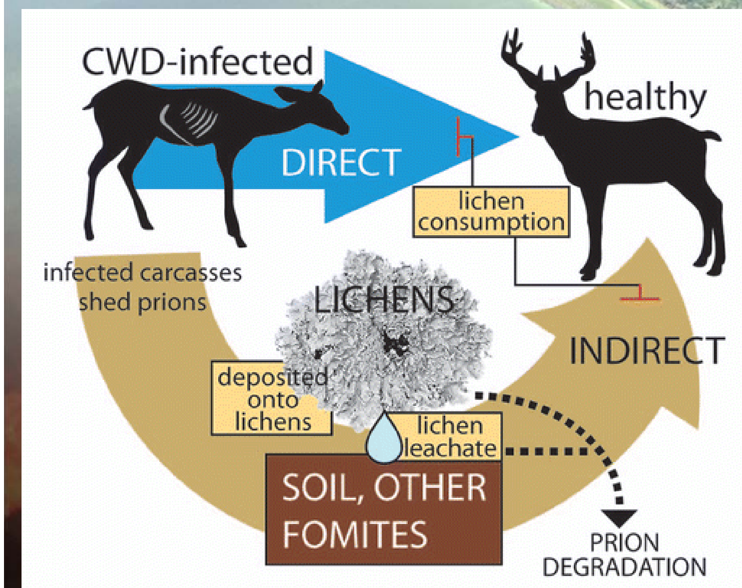
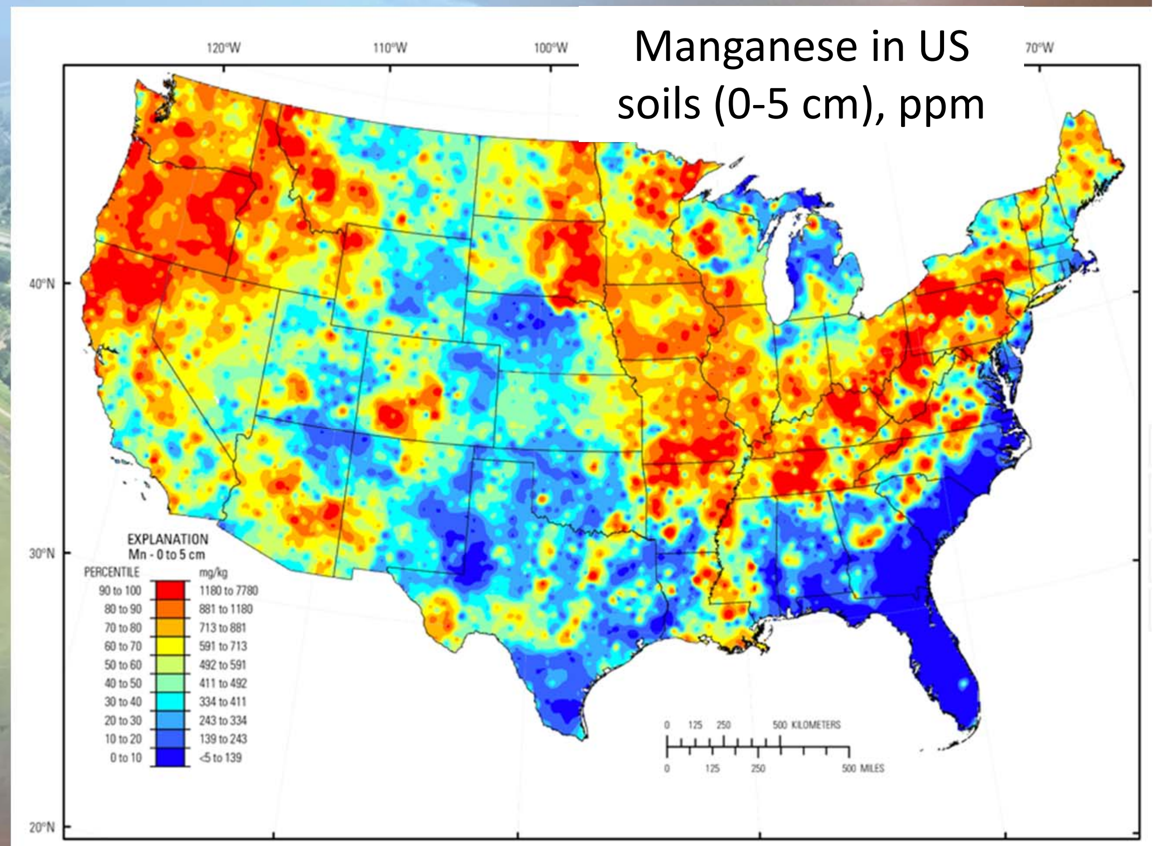
Environmental persistence of prions, the proteins that cause chronic wasting disease

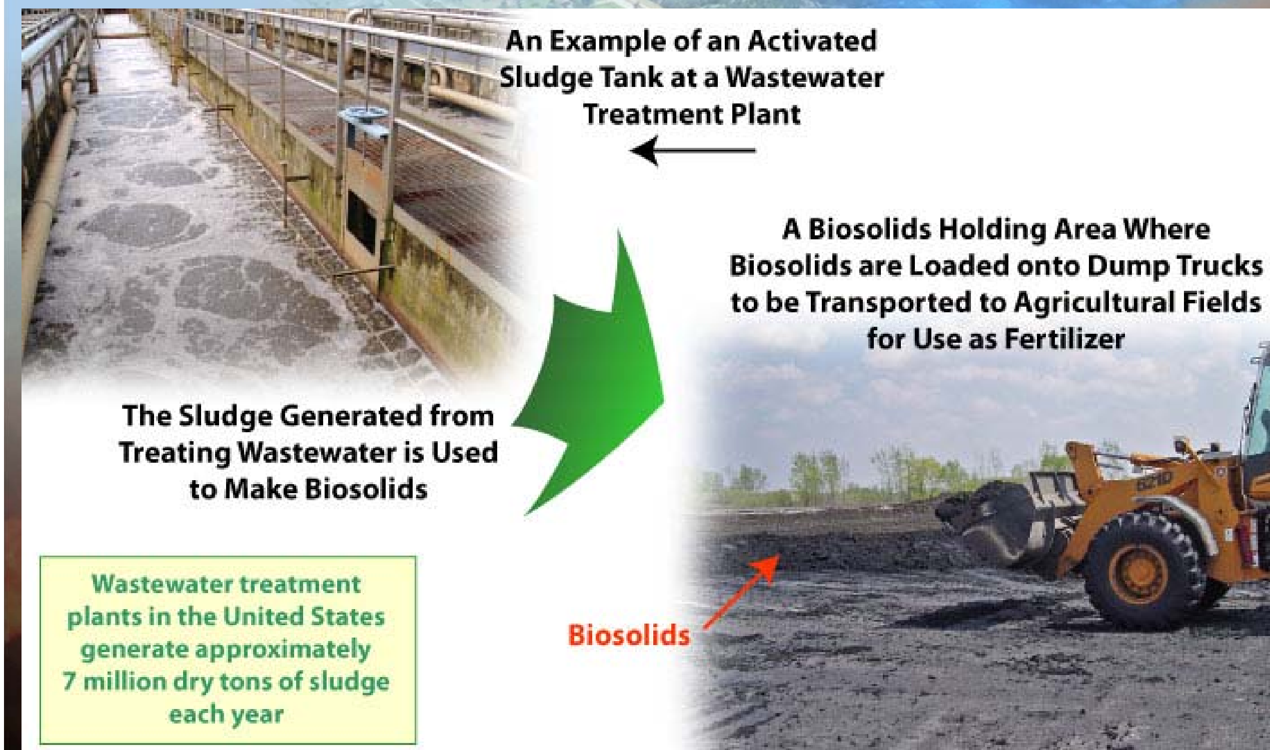




Degradation of prions by certain lichens and by manganese oxide minerals found in soils.

Christopher Johnson, Bryan Richards, USGS, and colleagues

Environmental persistence of prions, the proteins that cause chronic wasting disease



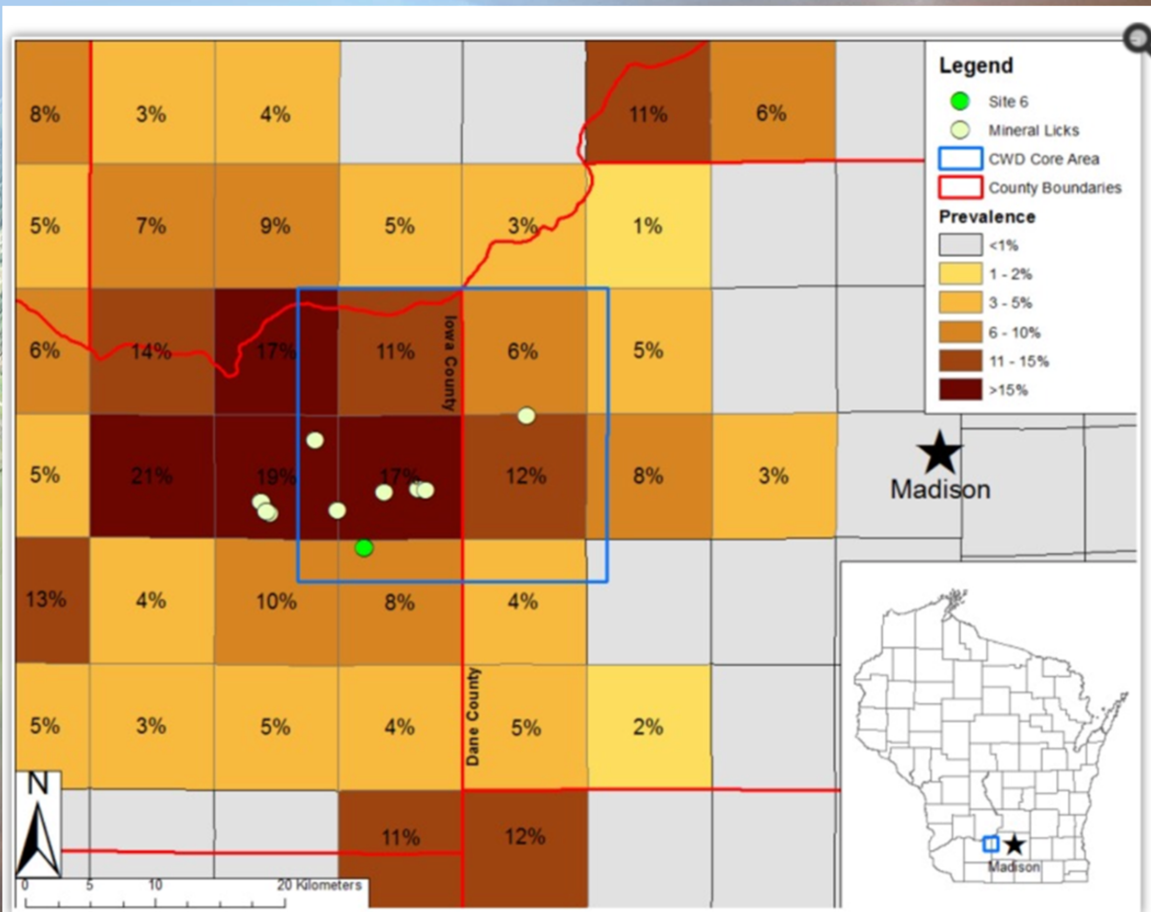
In wastewater treatment systems, most prions would partition to activated sludge solids, survive mesophilic anaerobic digestion, and be present in treated biosolids

Christopher Johnson, Bryan Richards, USGS, and colleagues

Environmental persistence of prions, the proteins that cause chronic wasting disease

Mineral licks and chronic wasting disease prevalence—do they provide potential for cross-species transmission?

UWI, with analytical assistance from USGS



Plummer et al., 2018, PLoS One 13(5) e0196745

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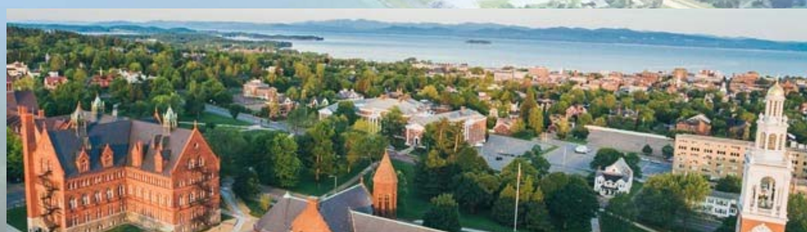
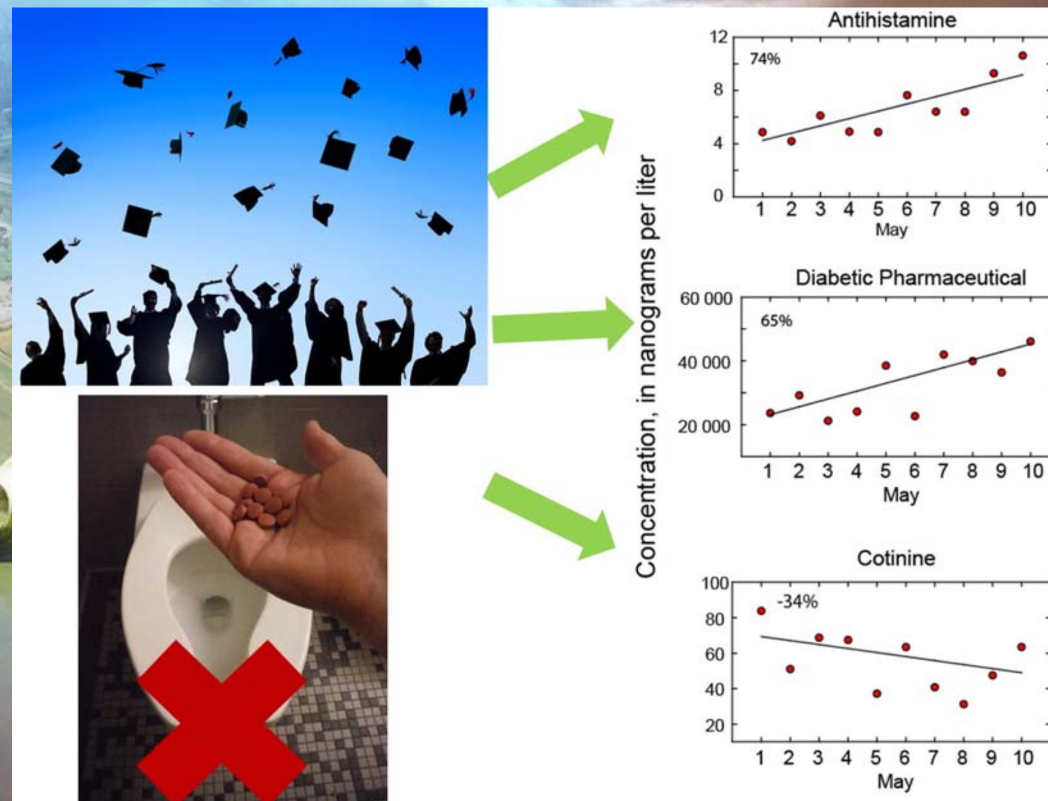
Investigating dynamic sources of pharmaceutical compounds in wastewaters

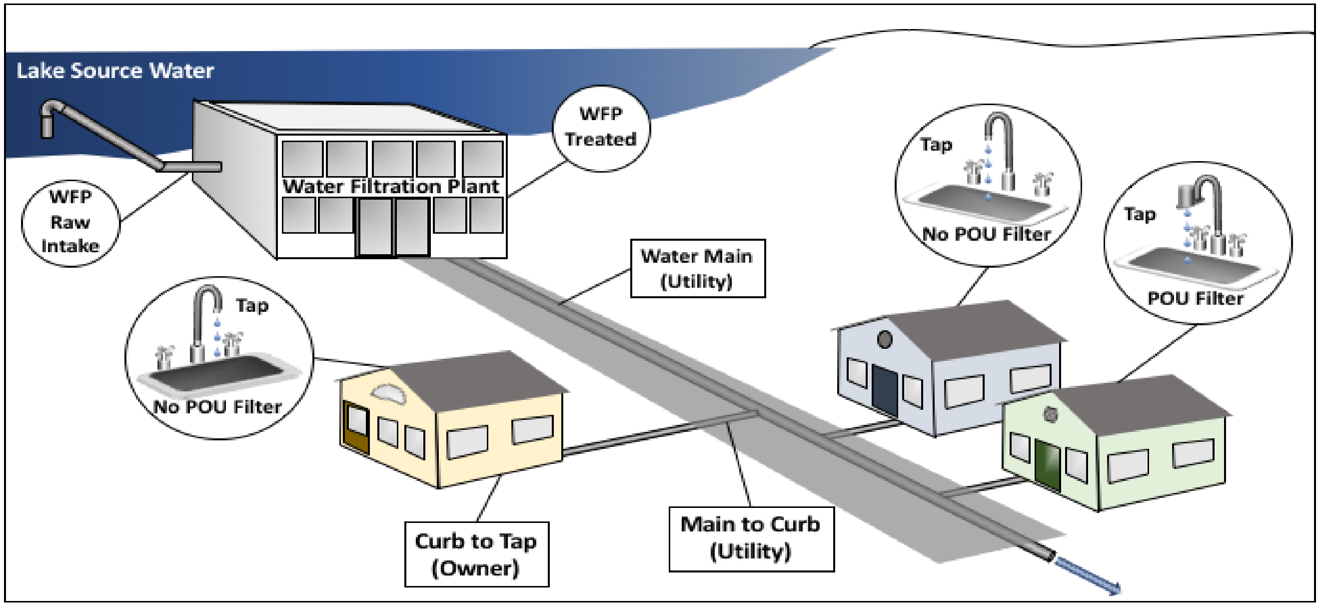




Patrick Phillips, Ed Furlong, and colleagues from University of Vermont

Vatovec et al., 2016, STOTEN, 572: [illegible]–914.

Contaminants and pathogens in tapwaters



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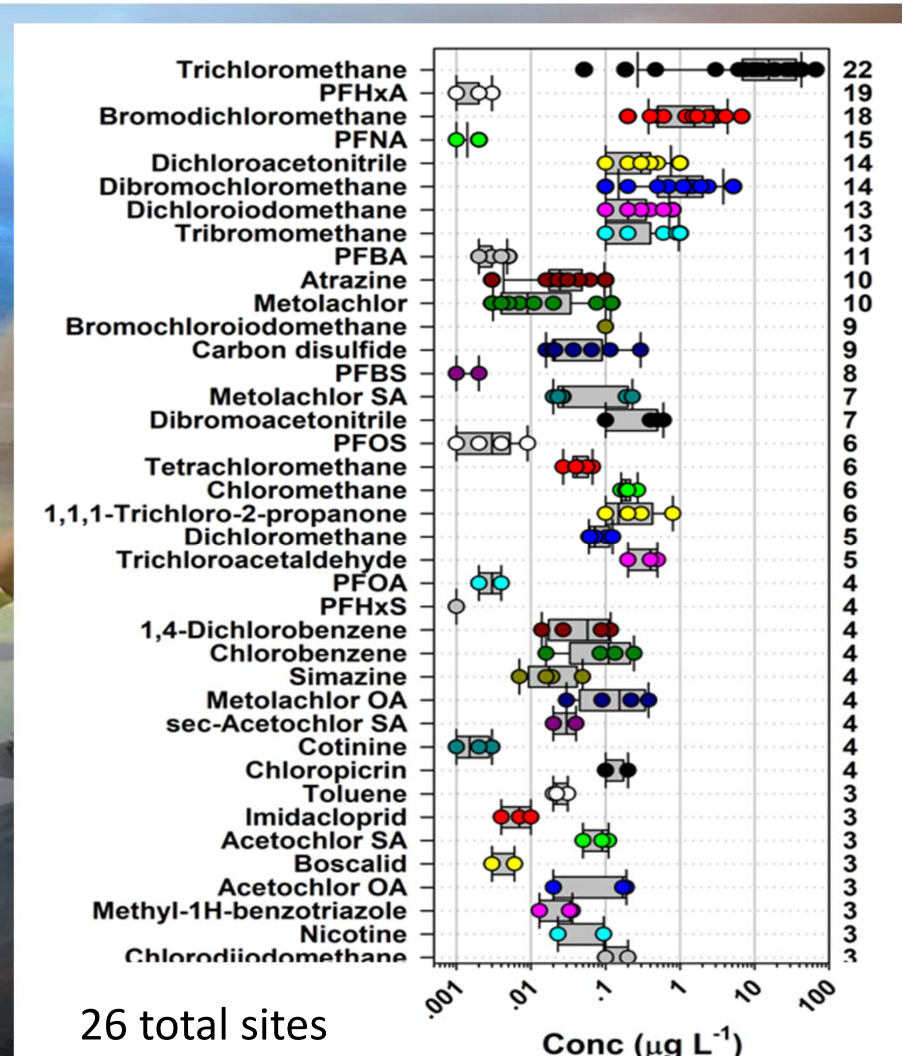
Reconnaissance of Chemical Contaminant Exposures from Residential and Workplace Tapwaters at Selected Sites in the U.S

- 482 organics, 19 inorganics
- USGS and Collaborators: NIEHS, EPA, Colorado School of Mines, Harvard School Pub Hlth
- Bradley et al., 2018, *Environmental Science & Technology* **2018** *52* (23), 13972-13985



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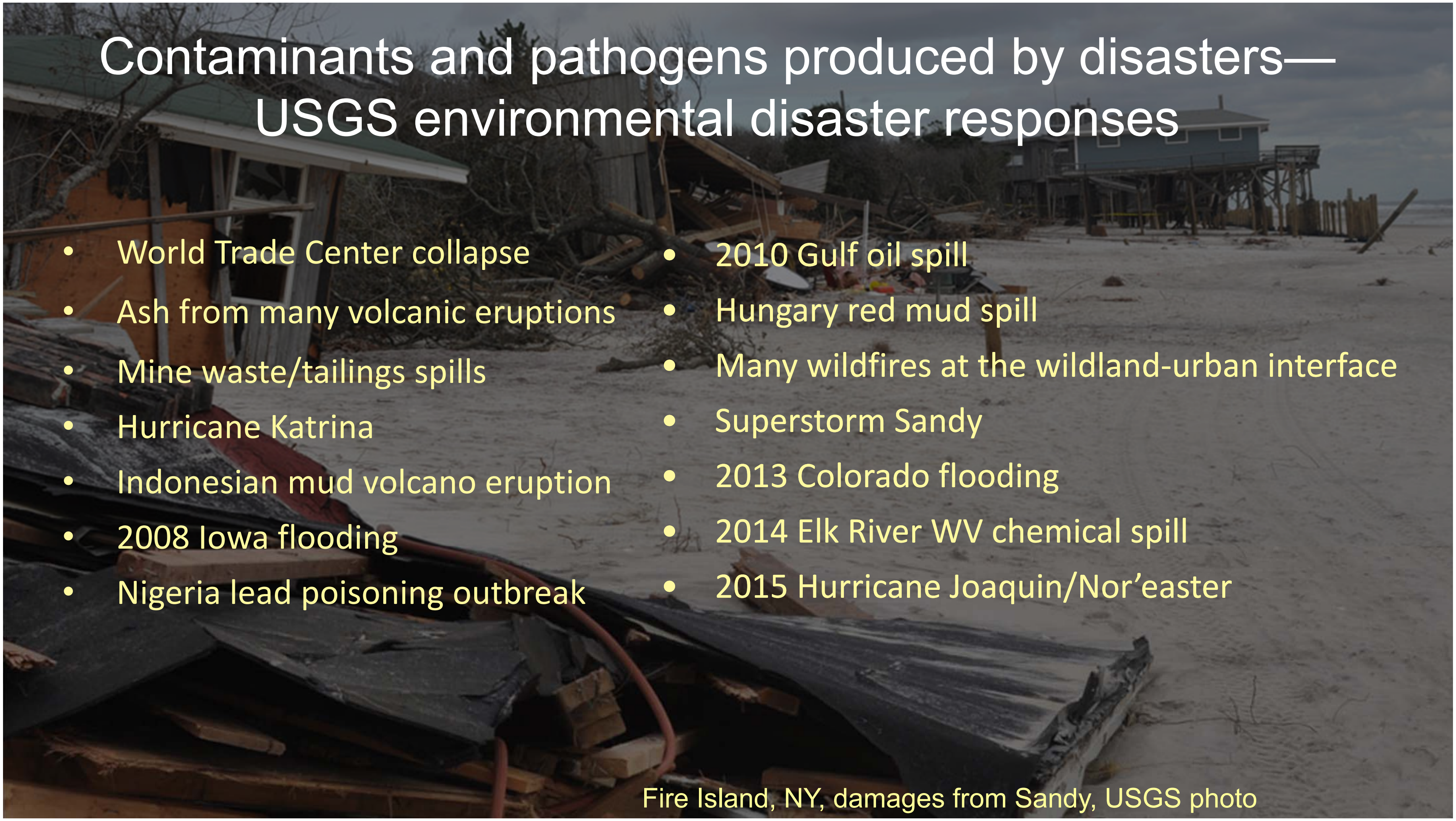
Preventing over-application of naled and other pesticides

- USGS worked with National Key Deer Refuge and Florida Keys Mosquito Control District to determine the maximum possible application rates for an insecticide that would control mosquitos (including the mosquito that carries zika virus), but that would not kill non-target butterflies.

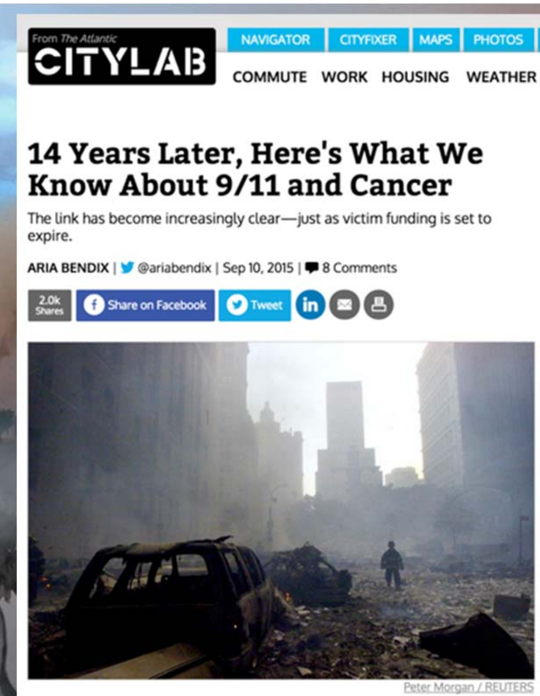
Contaminants and pathogens produced by disasters—USGS environmental disaster responses

- World Trade Center collapse
- Ash from many volcanic eruptions
- Mine waste/tailings spills
- Hurricane Katrina
- Indonesian mud volcano eruption
- 2008 Iowa flooding
- Nigeria lead poisoning outbreak
- 2010 Gulf oil spill
- Hungary red mud spill
- Many wildfires at the wildland-urban interface
- Superstorm Sandy
- 2013 Colorado flooding
- 2014 Elk River WV chemical spill
- 2015 Hurricane Joaquin/Nor'easter



Fire Island, NY, damages from Sandy, USGS photo

World Trade Center dusts



From The Atlantic CITYLAB

NAVIGATOR | CITYFIXER | MAPS | PHOTOS

COMMUTE WORK HOUSING WEATHER

14 Years Later, Here's What We Know About 9/11 and Cancer

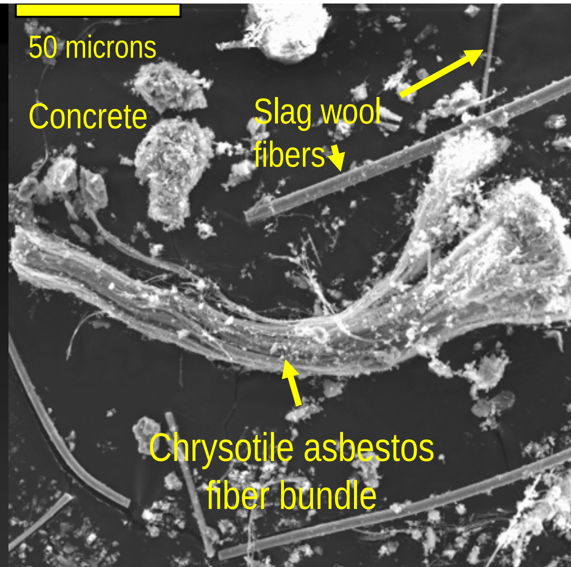
The link has become increasingly clear—just as victim funding is set to expire.

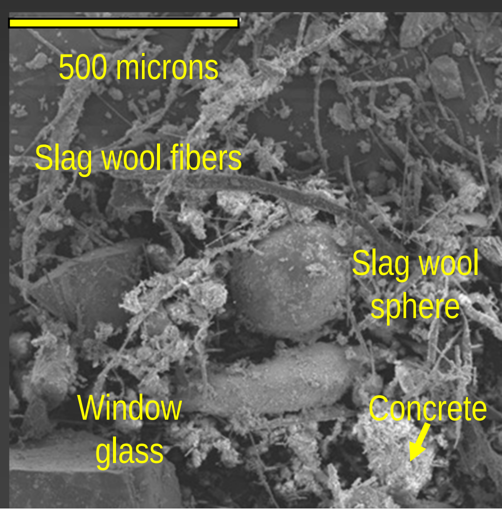
ARIA BENDIX | @ariabendix | Sep 10, 2015 | 8 Comments

2.0k Shares | Share on Facebook | Tweet

Peter Morgan / REUTERS

Photo by Mark Rushing





World Trade Center dusts

- Gypsum, slag wool, window glass
- Caustic calcium hydroxide from concrete
- Bioaccessible lead (from paint, solder, etc.), antimony (fire retardant), and hexavalent chromium and nickel fiers (girder coatings)
- 2-3% chrysotile asbestos from girder coating, spray on textures, old ceiling tiles
- Polynuclear aromatic hydrocarbons, other organic contaminants
- Rainfall neutralized the caustic alkalinity, leached water-soluble gypsum, concentrated the lead in outdoor dusts

*Unique USGS results

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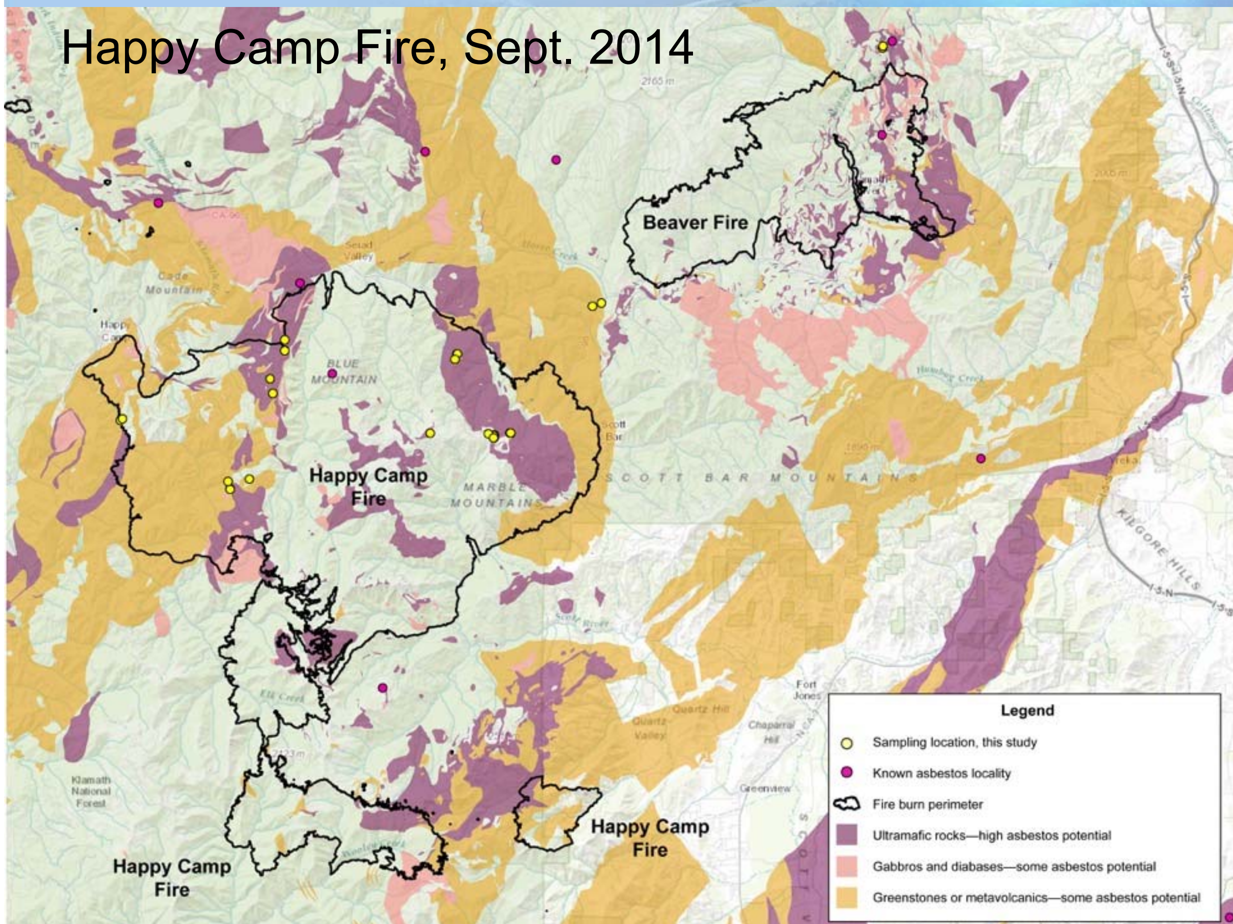
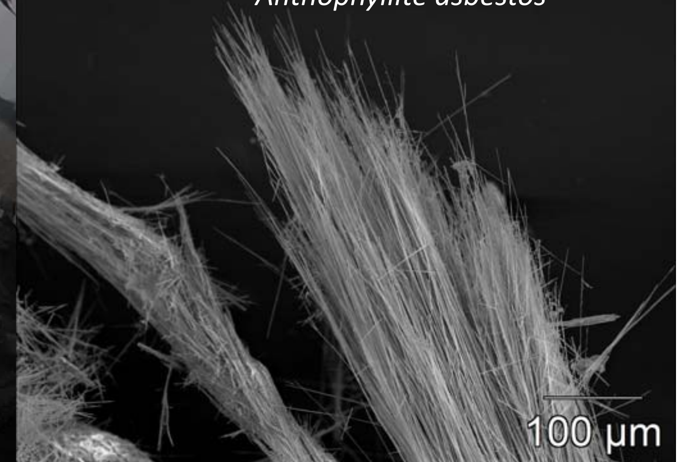
Wildfire ash, smoke, debris

Wildfire airfall, residual ash, debris

Wildfires on rocks having natural asbestos



Anthophyllite asbestos



Origins of deployment-related respiratory disease

Veterans Sound Alarm Over Burn-Pit Exposure

By JAMES RISEN
Published: August 6, 2010

The New York Times

WASHINGTON — When former Staff Sgt. Susan Clifford was stationed in 2004 and 2005 at Balad Air Base in Iraq, she was assigned to help dump her Army unit's trash into a massive, open-air pit.

Enlarge This Image

Marko Drobnjakovic/Associated Press

Army soldiers burning waste at an outpost in Iraq in 2007. The Pentagon has since restricted the use of such burn pits.

Every conceivable type of waste was piled high in the pit — plastics, batteries, appliances, medicine, dead animals, even human body parts — and burned, with a dousing of jet fuel. A huge black plume of smoke hung over the pit, nearly blinding Ms. Clifford on her twice-a-month visits, and wafted over the entire base.

RECOMMEND
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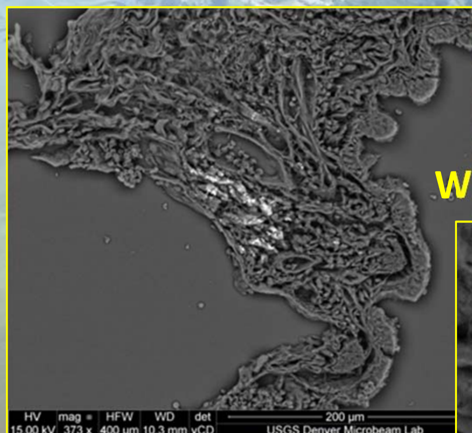
SIGN IN TO E-MAIL
PRINT
REPRINTS
SHARE

http://www.nytimes.com/2010/08/07/us/07burn.html

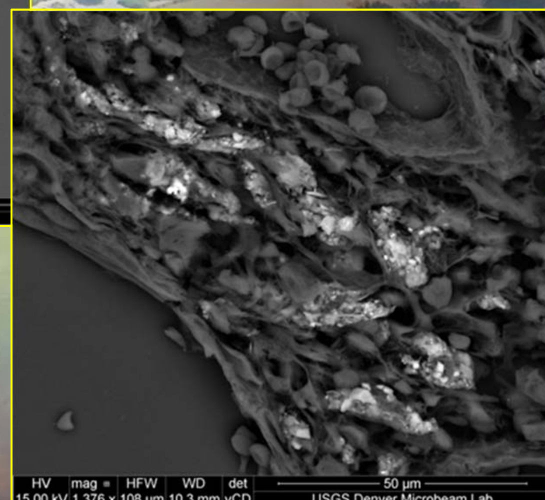
Characterizing mineral matter in biopsied lung tissue samples from deployers, (+) controls, (-) controls

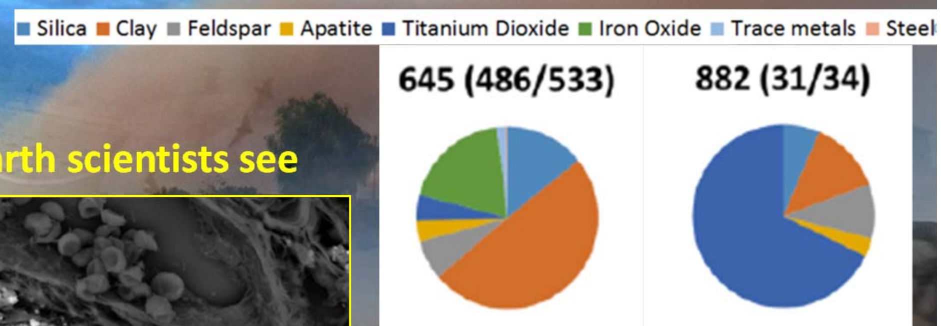
USGS with National Jewish Health, DoD funded

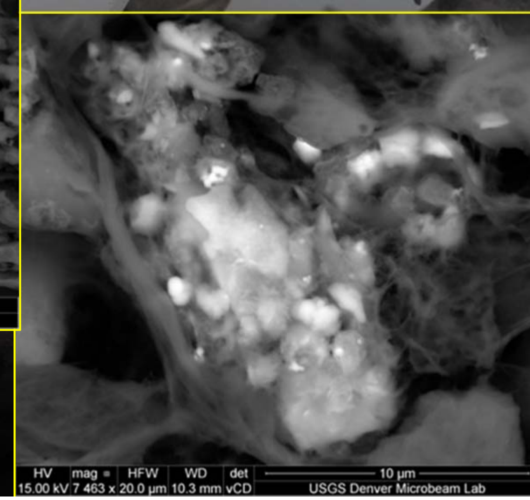
Lowers et. al, 2018, Toxicology Mechanisms and Methods, https://doi.org/10.1080/15376516.2018.1449042



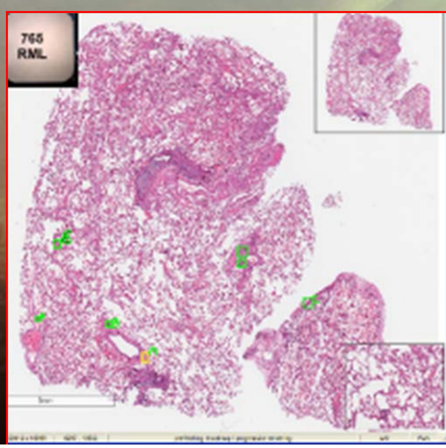
What the earth scientists see







What the pathologists see



Heather Lowers, George Breit
Geoff Plumlee
Greg Meeker

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Key takeaways

- There are many environmental contaminants and pathogens of emerging concern.
- Understanding whether or not they pose an actual risk, and helping mitigate or remediate actual risks, requires a transdisciplinary science approach involving collaborations between earth, biological, medical, public health, engineering, and other disciplines.