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  

National Environmental Monitoring Conference  
August 7, 2019
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
Environmental contaminants and pathogens of emerging concern

- Others are relatively recently recognized
Cyanobacterial and other toxins produced by harmful algal blooms

Toxins produced by freshwater blooms

Toxins produced by marine 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
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/
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
Poly- and Perfluoroalkyl (PFAS) compounds

- Can persist through drinking water treatment

Dana Kolpin, Ed Furlong, and colleagues.
Poly- and Perfluoroalkyl (PFAS) compounds

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

Tree swallows, photo by Keith Williams, USGS
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
Investigating dynamic sources of pharmaceutical compounds in wastewaters

Patrick Phillips, Ed Furlong, and colleagues from University of Vermont. Vatovec et al., 2016, STOTEN, 572: 90—914.
Contaminants and pathogens in tapwaters
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

26 total sites
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 mosquitoes (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

- 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
Wildfire ash, smoke, debris
Wildfire airfall, residual ash, debris
Wildfires on rocks having natural asbestos

Happy Camp Fire, Sept. 2014

Anthophyllite asbestos

Legend
- Sampling location, this study
- Known asbestos locality
- Fire burn perimeter
- Ultramafic rocks—high asbestos potential
- Gabbros and diabases—some asbestos potential
- Greenstones or metavolcanics—some asbestos potential

100 μm
Veterans Sound Alarm Over Burn-Pit Exposure

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.

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.

Characterizing mineral matter in biopsied lung tissue samples from deployers, (+) controls, (-) controls
USGS with National Jewish Health, DoD funded

What the pathologists see

What the earth scientists see


Heather Lowers, George Breit, Geoff Plumlee, Greg Meeker
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.