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Water Quality Monitoring in the Pacific Northwest

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A look at common water quality tests, why they matter, and where do regulatory agencies fit in

The Bigger Picture

Your Role

How Testing Relates To Your Job

Roles

- Regulatory
- Private entity
- Manager
- Tribal entity
- Municipal, county official, clerk
- Operator
- Technical assistance provider
- Interested party

Drinking Water Testing

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Why Test?

- Public health
- Environmental aspects
- Regulatory

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Drinking Water Testing

General

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Think About It

Required tests?

Where to find information?

- Monitoring and Compliance Schedule
- NPDES Permit
- Related project documents

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National Primary Drinking Water Regulations

Primary Standards

Enforceable - apply to public water systems

Protect health by limiting levels of contaminants in drinking water

National Secondary Drinking Water Regulations

Secondary Standards

Non-enforceable guidelines – regulate contaminants that may cause **cosmetic effects** (skin or tooth discoloration) or **aesthetic effects** (such as taste, odor, color) in drinking water

Aluminum, chloride, fluoride, color, iron, etc.

Comparison

Primary standards - Federal-level, legally binding mandates focused on public health

Secondary standards – Broader look at what makes public drinking water appealing and accessible

General Microbiology and Chemical Contaminants

Put on your lab coat

Don’t Forget Your PPE!

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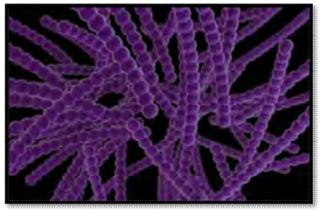
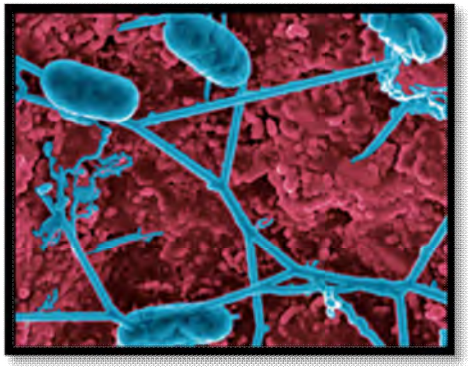
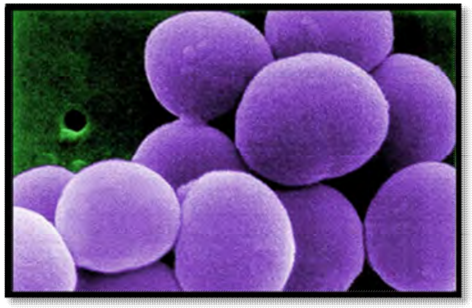
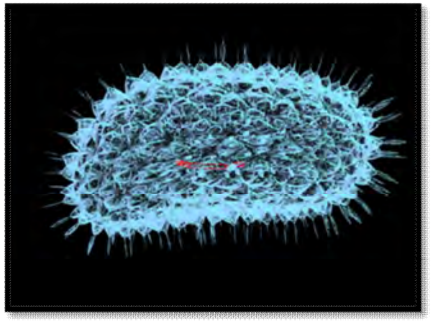
Microbes

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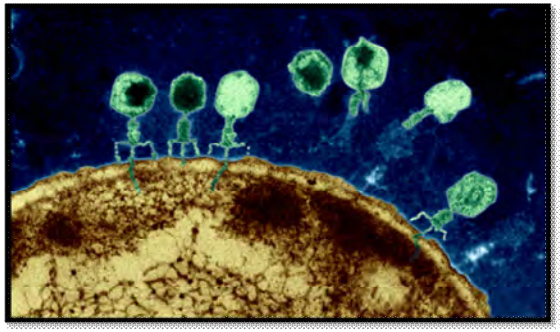
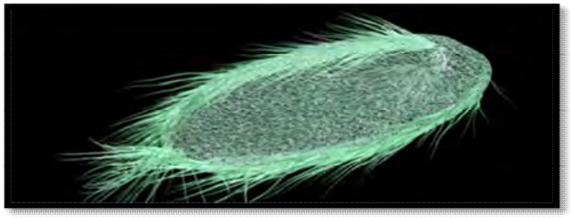
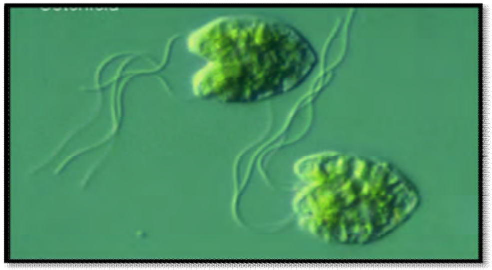
Electron Microscope







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Microbial Safety

Microbial safety is based on **multiple barriers**, from catchment to consumer

- Protection of resources
- Proper selection and operation of treatment steps
- Management of distribution systems

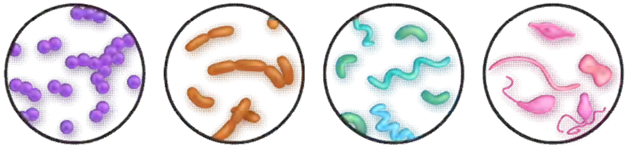
Microbial Risks

Greatest risks are associated with ingestion of water contaminated with human or animal feces (pathogenic bacteria, viruses, etc.)

Water quality can vary rapidly resulting in potential outbreaks

By detection, many people can be exposed

Bacterial Pathogens



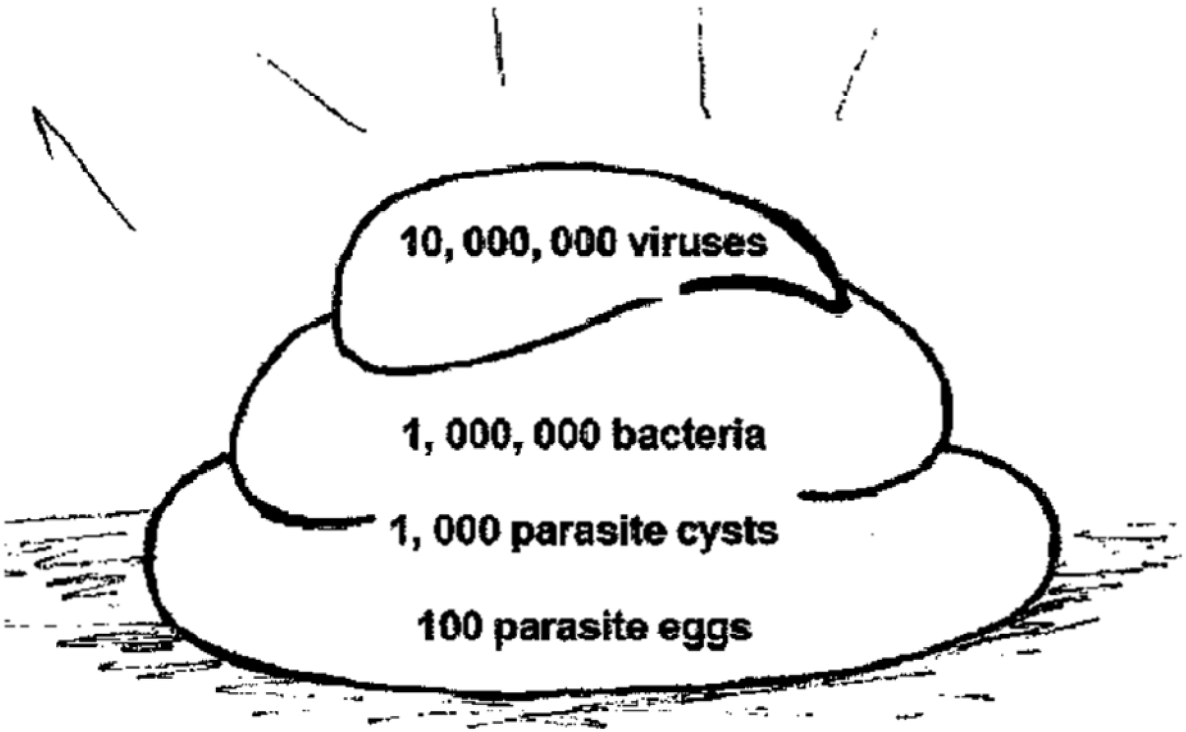
Most infect GI system – excreted in feces

Can grow in water and soil

Some easier to kill than others

Yuck!

- This is because ONE single gram of human faeces can contain up to:



Environmental Finance Center
EPA REGION 10

Total Coliform and Fecal Coliform

“Bacteria Test”

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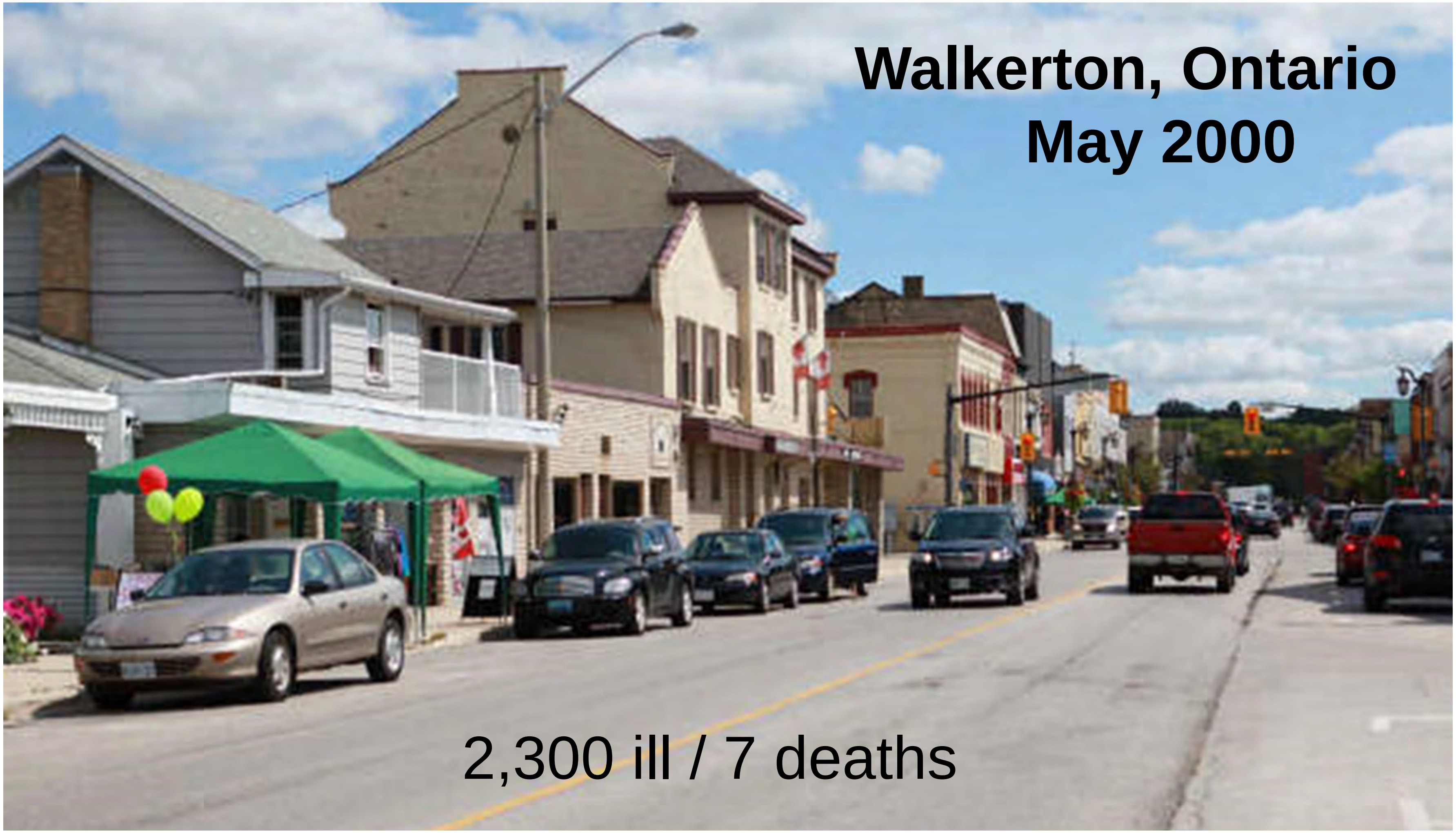
Why Do We Care?



Contributing Failures

Microbial contamination of groundwater

Ran well(s) - no operational chlorinator

Fictitious residuals - operations sheets

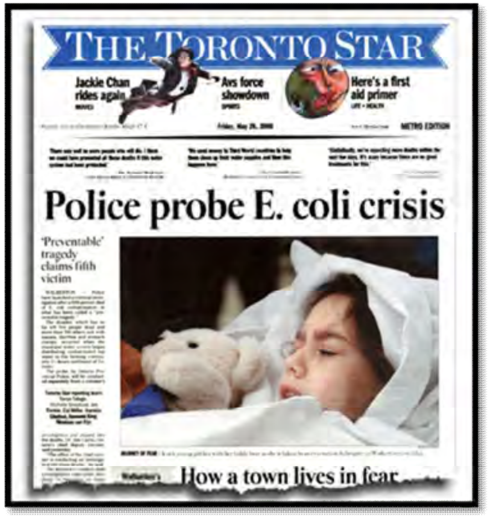
False labels

Hid positive results

No operator training / oversight

False reports

Delayed “Boil Order”


THE TORONTO STAR

Jackie Chan rides again

Avs force showdown

Here's a first aid primer

Police probe E. coli crisis

'Preventable' tragedy claims fifth victim

How a town lives in fear

Total and Fecal Coliform

Walkerton was preventable

Monitoring residuals and bacteria are important tools to provide safe drinking water to communities

Where Are Coliform Bacteria Found?

Occur naturally in

- Animal and human digestive tracts (feces)
- Plant and soil material
- Sediment
- Biofilms
- Untreated water

Ubiquitous, not pathogenic

Where Are Coliform Bacteria Found?

Most surface water supplies

Some groundwater sources

- Agricultural runoff
- Wastewater influences
- Source water contamination – soil runoff, WWTP effluents, septic tank failure, combined sewer overflows

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Total and Fecal Coliform

Water industry accepts that if TC are present, conditions are right for pathogens to also grow

Does not mean they are present, but possible

Total and Fecal Coliform Bacteria

Inactivated by treatment

Contamination may be due to

- Inadequate disinfection
- Regrowth in distribution system
- Contamination of distribution system

Examples - Open / faulty storage reservoirs, animal droppings

Total and Fecal Coliform Bacteria

Total coliforms in a Public Water System:

- Should be **absent** with adequate chlorine residual
- Not necessarily a health threat in itself
- **Are an indicator of contamination**
- **Are a warning sign the system may be vulnerable to fecal contamination**
- Additional sampling is required to assess extent of problem

E. coli Happens

Present in human intestinal flora – not all pathogenic

Humans - main carrier, followed by animals

Chipotle - raw vegetables
Walkerton, Ontario, Canada 2000
Jack in the Box - Washington

Total and Fecal Coliform Bacteria

Detection of fecal coliform (or E. coli) can indicate contamination with fecal waste

- Causes - line breaks, cross-connections, compromised source

Immediate steps to confirm, inform and protect consumers may be needed

Attempt to determine problem and address it as quickly as possible

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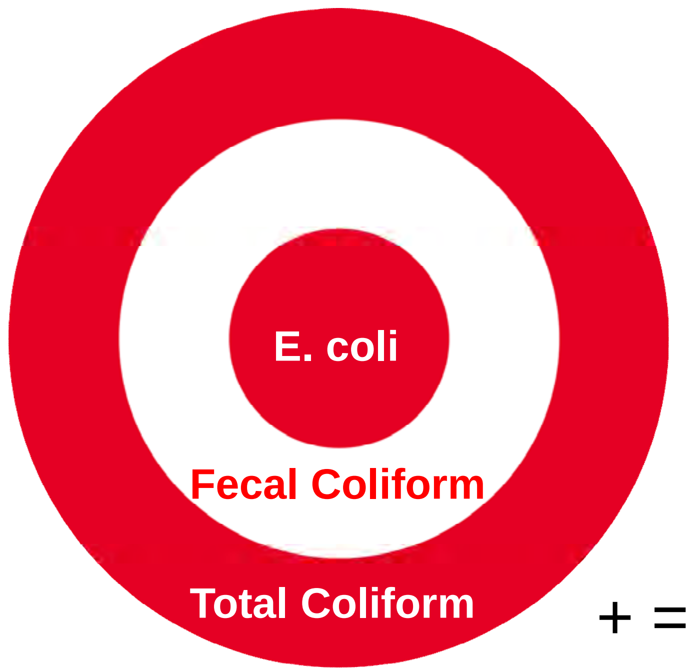
Indicator Organisms

Total Coliform - “indicator organism” for E. coli



\+ = potential for E. coli

Can have TC + and EC –

Can’t have EC + unless TC +

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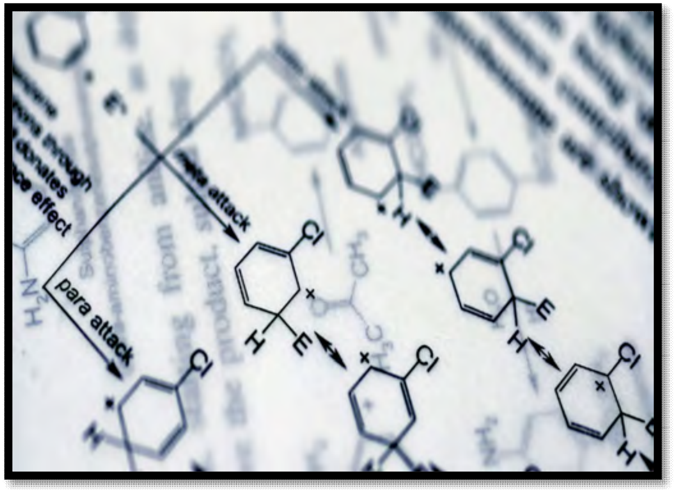
Other Contaminants

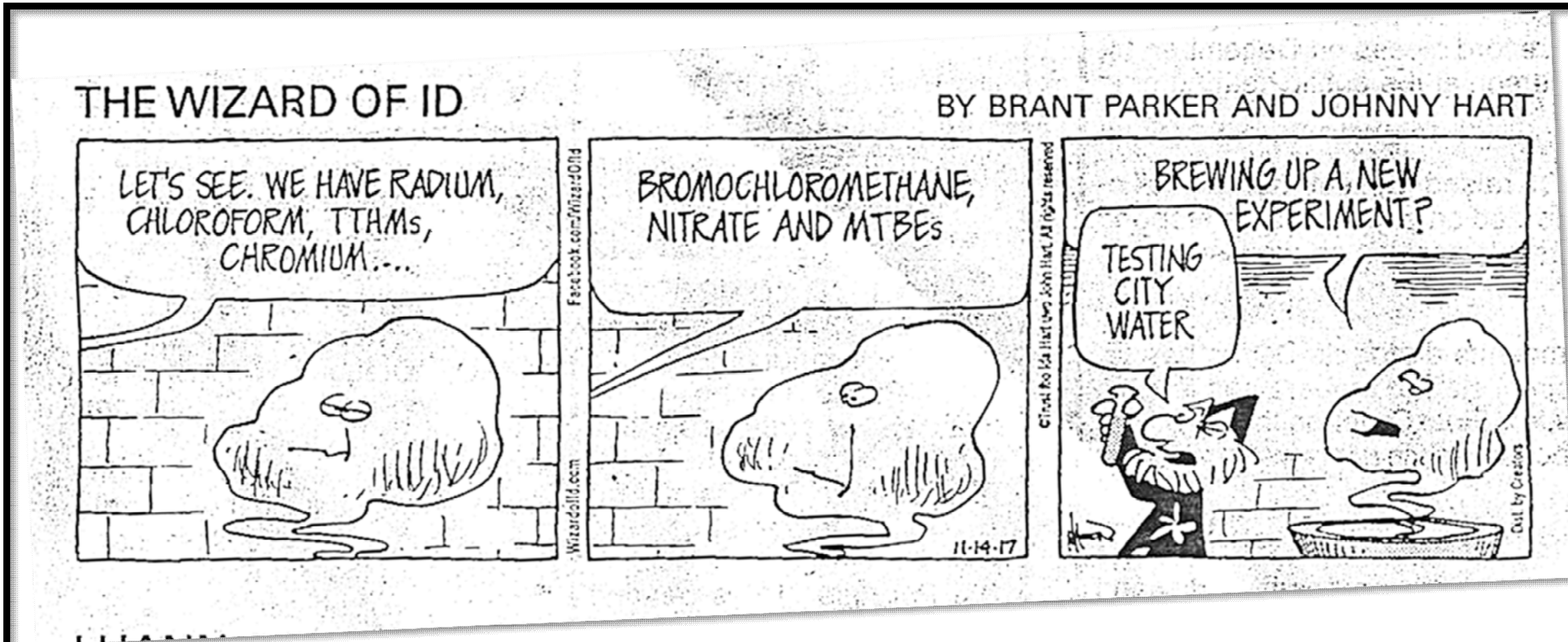
Drinking Water

Other Contaminants

Health concerns mainly from prolonged exposure

Occasionally from single incident (usually undrinkable - unacceptable taste, odor, appearance)





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Inorganic Compounds

IOCs

Nitrates

NO_3

Inorganic Compounds – Nitrate

NO_3

Essential component of living things

Major part of animal manure, human sewage waste, fertilizers - runoff unintentionally introduced to waterways

Can occur naturally in surface and ground water at low levels

Blue baby syndrome, thyroid, recurrent respiratory infections, spontaneous abortions, cancer

Arsenic

As

Inorganic Compounds – Arsenic

Occurs naturally in the common mineral arsenopyrite

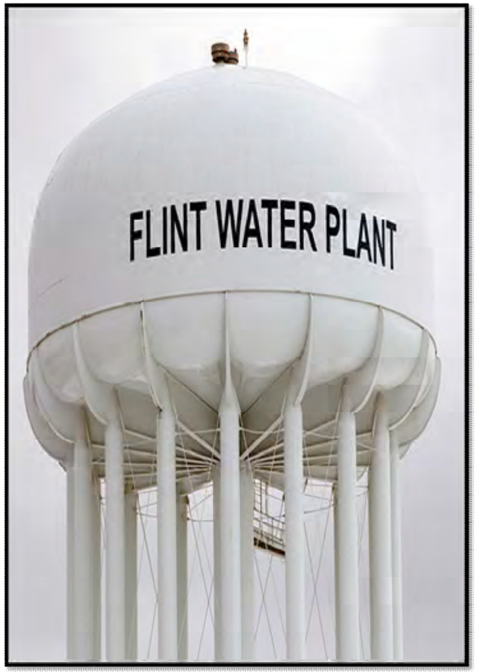
When rocks erode - released into the soil and groundwater

Human activities – mining, smelting ores, historically used in wood preservatives, agricultural chemicals

Lead and Copper

Pb and Cu

Inorganic Compounds - Lead



Corroded lead service lines

Neurotoxin - detrimental effect on developmental processes (behavior, intelligence, overall life achievement)

Revised Lead and Copper Rule

Inorganic Compounds - Copper

Corrosive water - blue-green stains at copper piping joints or the mouth of a faucet

Cognitive diseases and deficits

Directly and indirectly related to the development of Parkinson's disease, Alzheimer's disease, Huntington disease

Synthetic Organic Compounds

SOCs

SOCs

Man-made, organic (carbon-based) chemicals

Used as herbicides, insecticides, pesticides

Agricultural areas, urban settings, industrial runoff

Atrazine, Glyphosate, 2,4-D, Alachlor, Lindane

Acute and chronic health effects – nervous system, kidneys

Volatile Organic Compounds

VOCs

VOCs

Human-made chemicals
  Vaporize in air, dissolve in water

Pervasive in daily life – ubiquitous

Paint, carpet, vinyl flooring, upholstery, solvents, dry-cleaning chemicals, fuels, formaldehyde

Eye, nose, throat irritation, central nervous system damage

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Asbestos

Asbestos

Corrosion to outdated asbestos cement pipes (prior 1980s)

Naturally occurring deposits

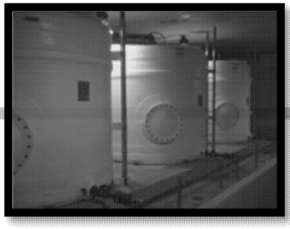
Debris from fires, floods, disasters

Chronic lung disease, mesothelioma

Disinfection By-Products

DBPs

DBPs



Formed when disinfectants (chlorine) interact with natural organic materials (surface water sources)

Over 600 DBPs identified (focus on a few) - THMs, HAAs, chlorite, bromate

Bladder cancer, small birth weight, miscarriages

Disinfection vs Disinfection Byproducts (DBPs): A Complex Balancing Act

Radiologicals

Rads

Radiologicals

Radionuclides – radioactive atoms

Small amounts in almost all rock and soil, dissolve in water

Gross alpha, beta emitters, radon, uranium, radium 226/228

Emerging Contaminants

Emerging Contaminants

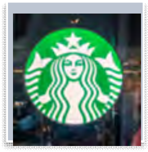
PFAS

Headlines

Starbucks announces ban of toxic “forever chemicals” in its food packaging

Dangerous PFAS Chemicals Are in Your Food Packaging

How the way we eliminate toxic PFAS from water also takes an environmental toll



Forever chemical found in wells 25 miles from Dupont plant

Most face masks don’t expose wearers to harmful levels of PFAS

Producers warned by EPA that PFAS is contaminating pesticides and food

Getting PFAS out of makeup might be easier said than done

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PFAS

Basics

Basics

Teflon - first PFA chemical

Discovered in 1938 by accident

Compounds that make our lives more convenient

Resist corrosion, withstand high heat, repel water

Paper food packaging materials less likely to absorb grease

Migrate into food

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Basics

Carbon-Fluorine bond

Chemically, thermally stable

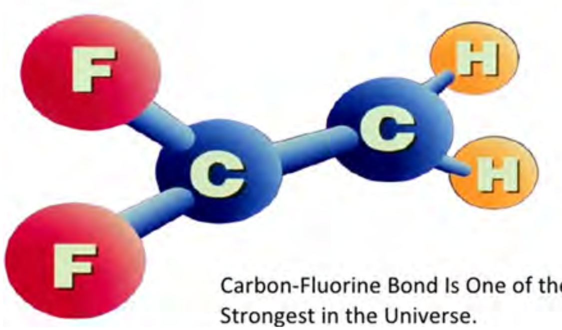
Water soluble, non-volatile

Man-made

Do not biodegrade

Resist heat, oils, grease, stains, and water

Widespread in environment



Carbon-Fluorine Bond Is One of the Strongest in the Universe.

Basics

PFAS – Per- and polyfluoroalkyl substances

PFOS – Perfluorooctanesulfonic acid

PFOA – Perfluorooctanoic acid

The Science

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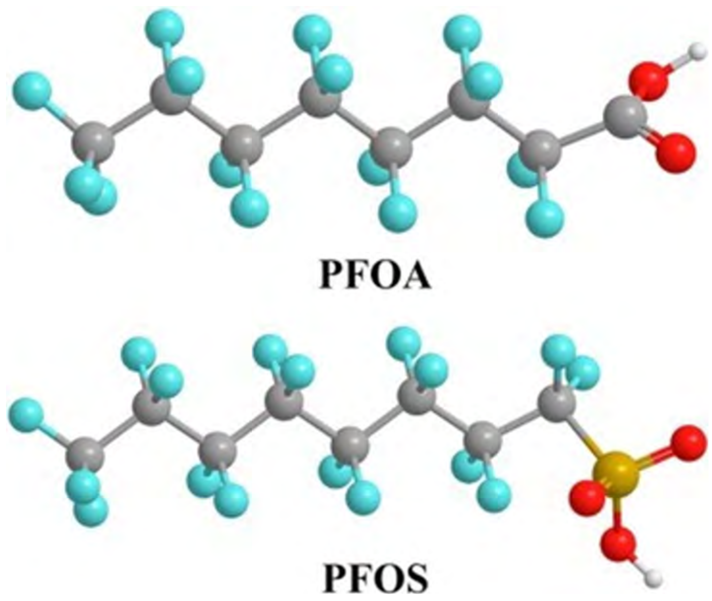
Basics

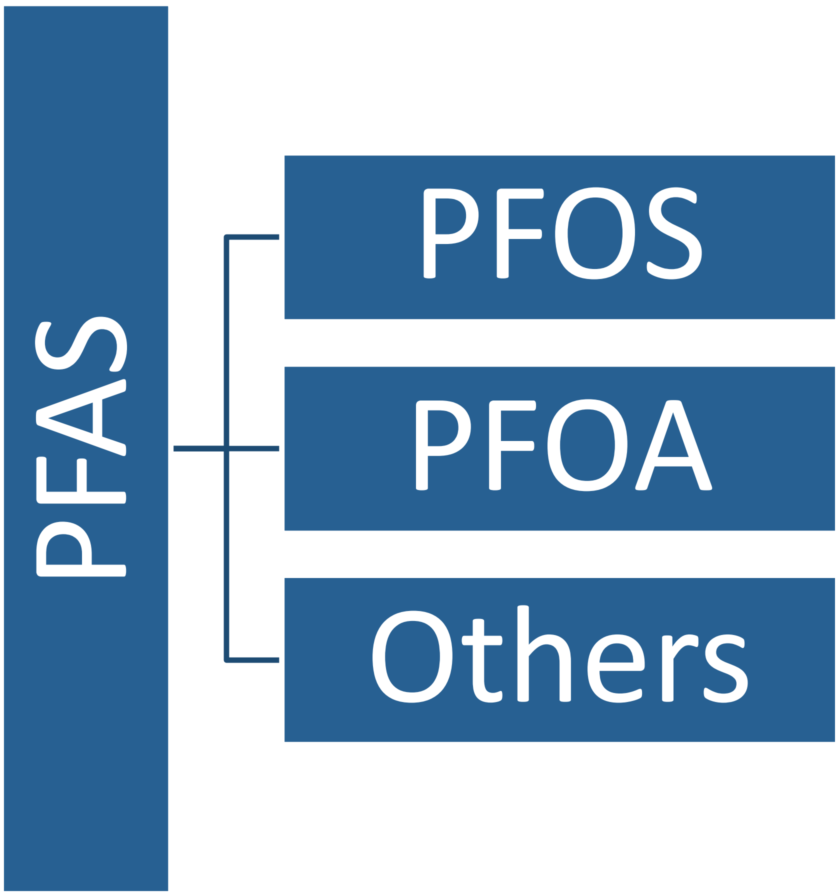


PFOA and PFOS - most studied and regulated

Long and short chain

Long chain - more persistent and potent

Basics



PFTriA, PFDoA, PFUnA, PFDA, PFNA, PFHpA, PFHxA, PFPeA, PFBA, PFDS, PFNS, PFHpS, PFHxS, PFPeS, PFBS, PFPrS, PFOSA, PFHxSA, PFBSA, PFMOBA, PFMOPrA, PFMOAA, PFO4DA, PFO3OA, PFO2HxA, FtS 8:2, FtS 6:2, FtS 4:2, N-EtFOSAA, N-MeFOSAA, ADONA, PFECHS, F35-B, Nafion BP2, and GenX

Basics - Why the Concern?

- Pervasive
- Persistent
- Bioaccumulate
- Adverse health effects
- Scarcity of information
- Lack of sufficient standards

PFAS

Sources

Sources

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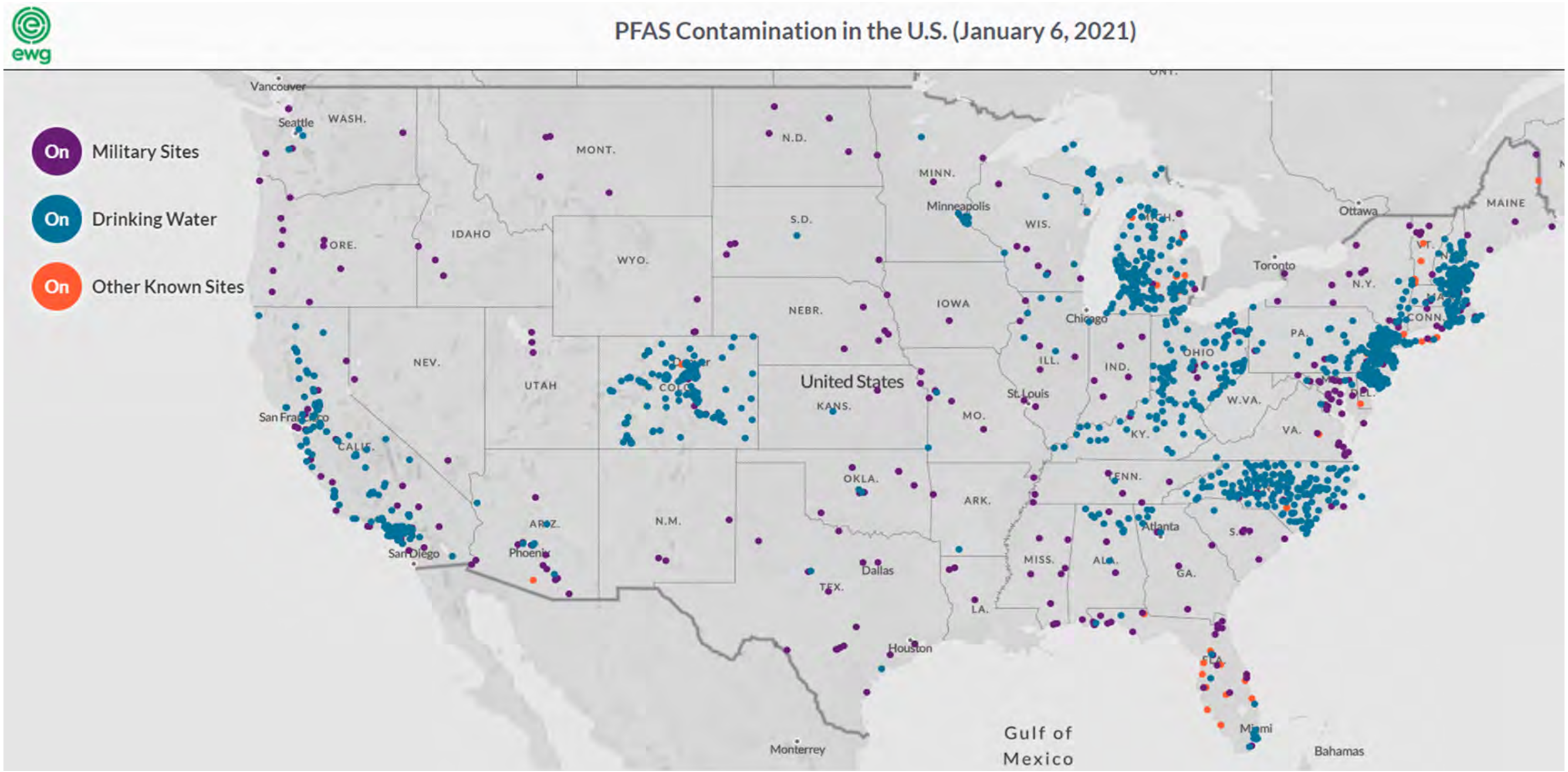
Sources

- Exposure from air, dust, water, food, products
- Fire training facilities, fire stations
- Military bases
- Airports
- Landfills
- Chemical, industrial facilities
- Carpet manufacturers
- Wastewater treatment plant effluent

Sources



https://www.ewg.org/interactive-maps/pfas_contamination/map/

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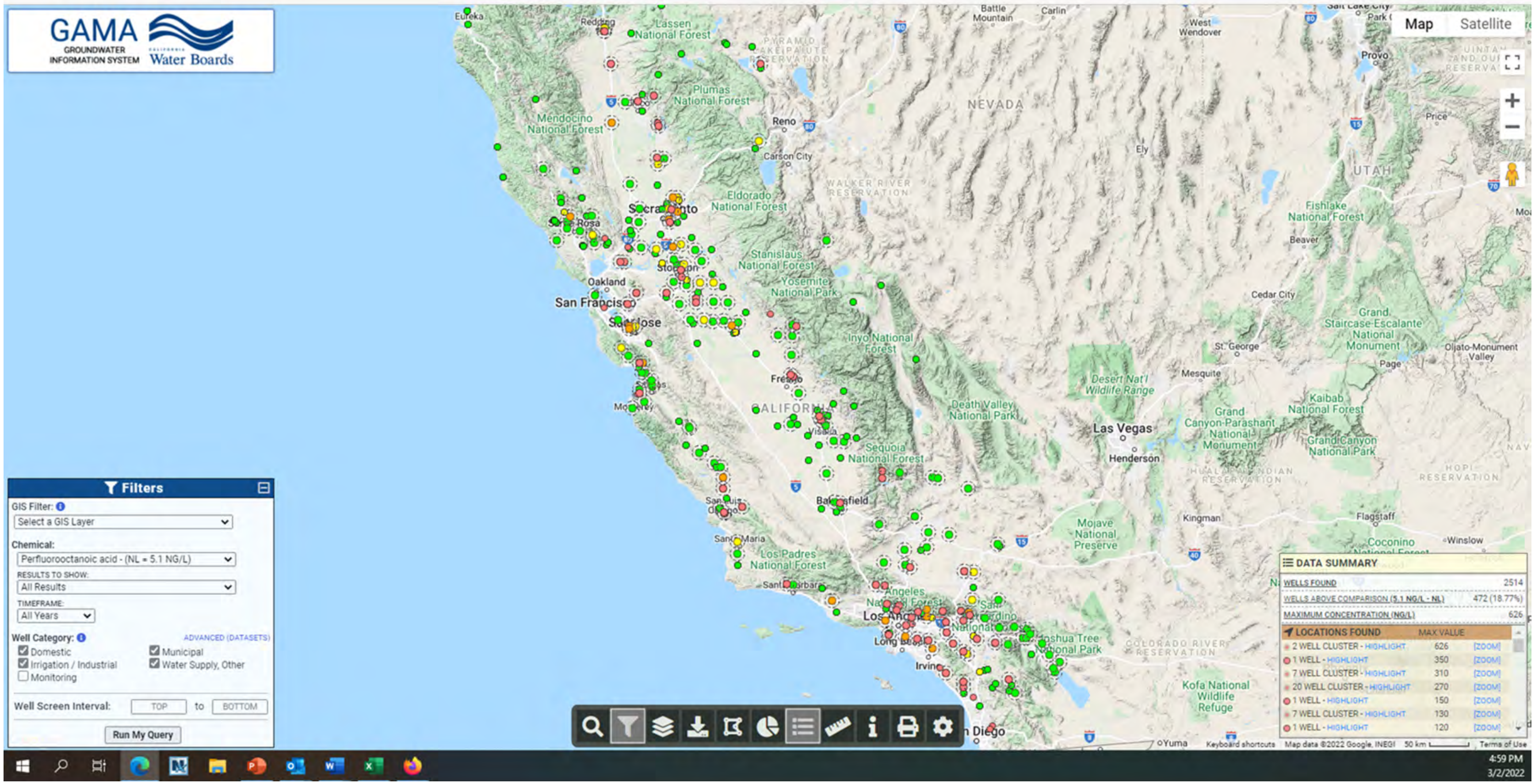
Sources



https://www.ewg.org/interactive-maps/pfas_contamination/map/

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Challenge

Think about potential sources in your region or community

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PFAS

Environmental and Health Impacts

Environmental and Health Impacts

Emitted into air and water

Can enter groundwater or surface water through waste and sewage sludge disposal

Detected in waters world-wide

Found in 95% to 100% of blood samples in humans / animals

Numerous adverse health effects

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PFAS

Regulations

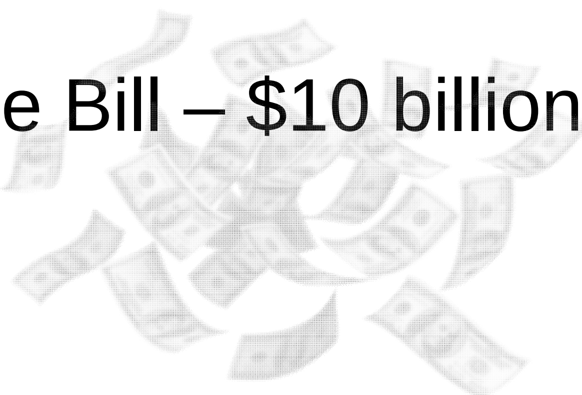
Regulations

Health Advisory Level – 70 ppt, non-enforceable (3.5 drops water in an Olympic-size pool)

2022 EPA plans to regulate PFOS/PFOA (MCL)

UCMR5 – 29 PFAS and lithium

2021 Infrastructure Bill – $10 billion for testing/treating



Emerging Contaminants

Cyanobacteria and Cyanotoxins

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General

Most algae species not harmful

Harmful algal booms (HABs) – certain species bloom excessively, produce toxins

Different colors - Red Tide, blue-green algae

Cyanobacteria, share some algae characteristics

Causes, Detection

Photosynthetic bacteria-
surface waters

Extended direct sunlight

Elevated nutrient availability (phosphorus, nitrogen)

Elevated water temperature

pH changes

Calm, stagnant water flow,
lack of vertical mixing

Initial detection is qualitative, visual observation of bloom formation

- surface water discoloration (red, brown, green)
- thick, mat-like accumulations on surface and shoreline
- fish kills

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Effects

Harmful to environment, animals, human health

Bloom decay consumes oxygen - plant, animal die-off

Favorable conditions of light/nutrients, can produce toxins - can't tell by sight, taste, odor

Intracellular / extracellular toxins – different treatments

Exposure through recreational activities; dogs, birds, livestock - consumption of contaminated water

Nervous system, liver, skin

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Control Measures

Aeration

Mechanical mixing

Reservoir drawdown

Surface skimming

Algaecides

Barley straw

Coagulation

Flocculation

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Removal

Intracellular Cyanotoxins (Intact Cells)

- Membranes
- Coagulation / Sedimentation / Filtration
- Floatation
- Pre-treatment Oxidation

Extracellular Cyanotoxins (Dissolved)

- Membranes
- Potassium Permanganate
- Ozone, Chloramines, Chlorine dioxide, Free chlorine
- UV Radiation
- Activated carbon

Emerging Contaminants

Microplastics and Nanoplastics

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Microplastics

Modern society relies on plastic – almost all aspects of our lives

Used in everything from packaging, clothing, cars, toothbrushes

Mostly nonbiodegradable material ~400 years to break down

Microplastics and Nanoplastics

Primary micro- and nanoplastics: deliberately manufactured in products (shower gel, toothpaste)

Secondary micro- and nanoplastics: from degraded larger plastics (paints, tires, textiles)

Forms: Fibers (synthetic-polyester), microbeads (cosmetics, pcp), fragments, pellets (melted-larger products)

Microplastics

1 µm-5 mm

Nanoplastics

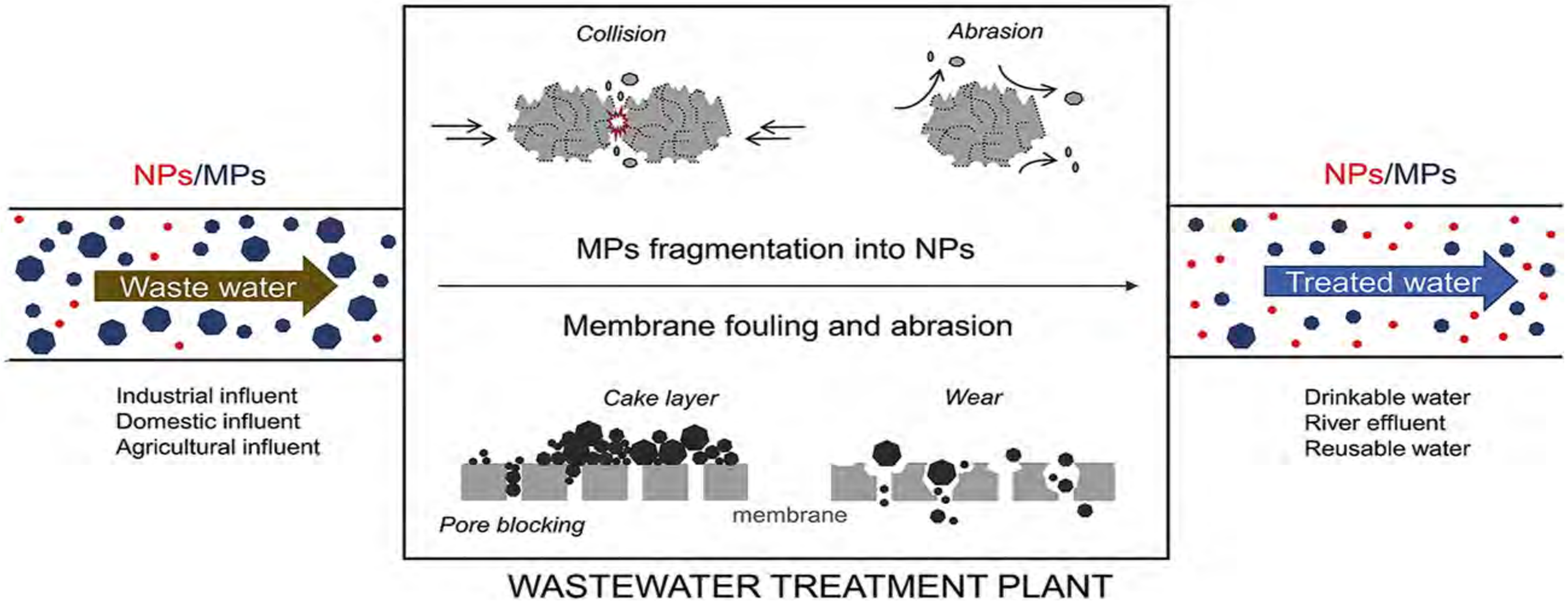
1-1000 nm

All corners of environment—land, water, air, bodies

Water-processing facilities not always able to detect (nature/size)

~30% ocean plastic pollution may derive from microplastics

Microplastics and Nanoplastics



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Microplastics and Nanoplastics

Solutions to limit impact on water and wastewater processes

- Pre-treatments
- Density separation
- Coagulation
- Biodegradation

Wastewater Testing

NOBODY TOLD JAMES THAT THE FIVE SECOND RULE DIDN'T APPLY IN THEIR LINE OF WORK.

Why Test?

- Public health – Preventing diseases
- Environmental aspects – Protecting people, fish, wildlife from pollution
- Regulatory – Permits, DMRs

Why Test?

Process monitoring and control

Optimize and maintain physical, chemical, and biological variables affecting treatment efficiency

Determine substances that are toxic or interfere with treatment system

Remove domestic and industrial pollutants and solids from the water and return clean water, biosolids and air back to the environment

Sampling Location

Depends on regulatory requirements, plant size, complexity

- Influent
- Effluent
- Mixed liquor
- Digester

Influent / Effluent

Influent

Raw wastewater coming in

Effluent

Treated wastewater for final discharge

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Types of samples

Grab

- Single sample of wastewater taken from a particular time and location

Composite

- Taken over time, typically 24 hours
- Time composite vs. flow proportioned

Continuous

Requires instrumentation and controls

pH, DO, turbidity, temperature, conductivity

Parameter	Container	Preservation	Maximum holding time
Bacteria	polypropylene or glass	cool, <10 °C, 0.0008% $Na_2S_2O_3$	6 hours
Volatile organic compounds	VOA vial	cool, 4 °C, 0.0008% $Na_2S_2O_3$, pH < 2 with HCL	14 days
Acidity ($CaCO_3$)	plastic or glass	cool, 4 °C	14 days
Alkalinity ($CaCO_3$)	plastic or glass	cool, 4 °C	
Ammonia (as N)	plastic or glass	cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand (BOD_5)	plastic or glass	cool, 4 °C	48 hours
Chemical oxygen demand (COD)	plastic or glass	cool, 4°C, H_2SO_4 to pH<2	28 days
Chlorine total residual	plastic or glass		analyze immediately
Color	plastic or glass	cool, 4 °C	48 hours
Hardness total ($CaCO_3$)	plastic or glass	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	plastic or glass		analyze immediately
Kjeldahl nitrogen total (as N)	plastic or glass	cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite (as N)	plastic or glass	cool, 4 °C	48 hours
Oil and grease	glass	cool, 4°C, H_2SO_4 or HCl to pH<2	28 days
Phosphorus total	glass	cool, 4 °C	48 hours
Turbidity	plastic or glass	cool, 4 °C	

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Tests - Physical Characteristics

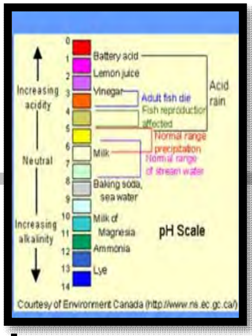
Temperature - thermal energy contained

Color – Amounts / types of matter present – dissolved, suspended, colloidal

Turbidity - quantity of suspended / colloidal material

Odor

Tests - Chemical Characteristics



Alkalinity – ability to neutralize acid

Chemical oxygen demand (COD) – how much oxygen a sample will consume

Conductivity - ability of an aqueous solution to carry an electrical current

Dissolved oxygen (DO) - molecular oxygen present in water

Oxidation-reduction potential (ORP) - ease of electron loss or gain

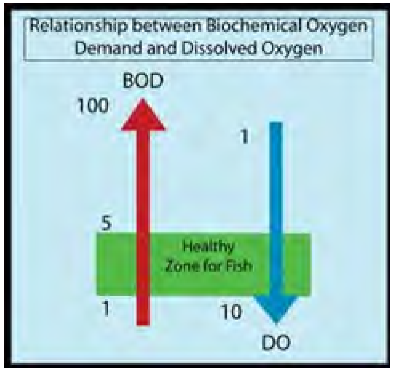
pH - concentration of hydrogen ions in a solution

Tests - Biochemical Characteristics

Biochemical oxygen demand (BOD) - amount of oxygen needed to biologically oxidize material in wastewater

Pathogens (E. coli) - disease-causing organisms

Viruses



Other Tests

O&G

TKN

Ammonia

Chlorine residual

Nitrate, nitrite

Total phosphorus

Solids (TS, TSS, TDS, VSS, VSS, VS, SS)

Chain-of-Custody

Possession

Clear communications and procedures from sample collection to reporting of results

Assures no sample tampering has occurred

Traceability

Shows who handled sample from collection, preservation, storage, and analysis

Chain-of-Custody

APPENDIX A. CHAIN OF CUSTODY FORM

CHAIN OF CUSTODY FORM

Sheet ____ of ____

Investigator
(name, address, ph & fax nos.)
Contact person:

Site

Laboratory
(name, address, ph & fax nos.)
Contact person:

Courier
(name, address, ph & fax nos.)
Contact person:

Sample ID	Laboratory ID	Container	Sampling		Sample matrix						Sample preservation					Analysis							
			Date	Time	WATER	SOIL	SLUDGE	OTHER (SPECIFY)	COMPOSITE		ICE	HNO_3/HCl	UNPRESERVED	OTHER (SPECIFY)									

Investigator: I attest that the proper field sampling procedures were used during the collection of these samples.			**Sampler name:** *(print & signature)*		*(Date)*
Relinquished by: *(print & signature)*	Date	Time	Received by: *(print & signature)*	Date	Time
Relinquished by: *(print & signature)*	Date	Time	Received by: *(print & signature)*	Date	Time
Relinquished by: *(print & signature)*	Date	Time	Received by: *(print & signature)*	Date	Time

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Compliance – required data

- DMR – daily monitoring report
- Data collection
- Frequency of analysis
  - This refers to how often you must collect and analyze samples for a particular parameter. The frequency varies by parameter but is usually designated as daily, weekly (or twice per week), or monthly.
- Sample type
  - The last column on the DMR is labeled “sample type,” which indicates whether the sample is to be a composite or a grab sample.

Questions?

"Mr. Osborne, may I be excused? My brain is full."

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