Emerging Contaminants PFAS and PFOA

APRIL 2023

Course objectives

- By the end of this course, participants will:
  - Understand the complexity and impacts of Emerging Contaminants
  - Understand UCMR 5 testing requirements
  - Be able to identify the sources of Emerging Contaminants
  - Learn how chemical development initiated Emerging Contaminants
  - Identify potential treatment options for their facilities

Emerging Contaminants

The various chemicals added to food, water and personal care products play significant roles in influencing human activities. They enable the development of new technologies and improve the standards and quality of life.

Chemicals enter the environment because of the widespread industrial activities taking place in our surroundings. These activities can release effluents (liquids or gases) and solid residues that can be harmful to the environment.

Emerging Contaminants refer to the materials or chemicals in the water, air, soil, or river sediments at relatively low concentration.

The contaminants are an actual or potential threat to any living organisms and the environment.

These chemicals are referred as *Emerging Contaminants* because:

- New technologies can now more easily detect them
- They have a new portal of entry into human beings and the environment

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Emerging Contaminants

"Emerging" does NOT mean these chemicals are NEW.

These chemicals have been being released into the environment for as long as they have been in use.

- Experimental studies show that contaminants attach themselves to different particles and compounds while being transported to the wastewater treatment plants.
- The level of the contaminants in drinking water and wastewater depends on the *source* of the contamination.

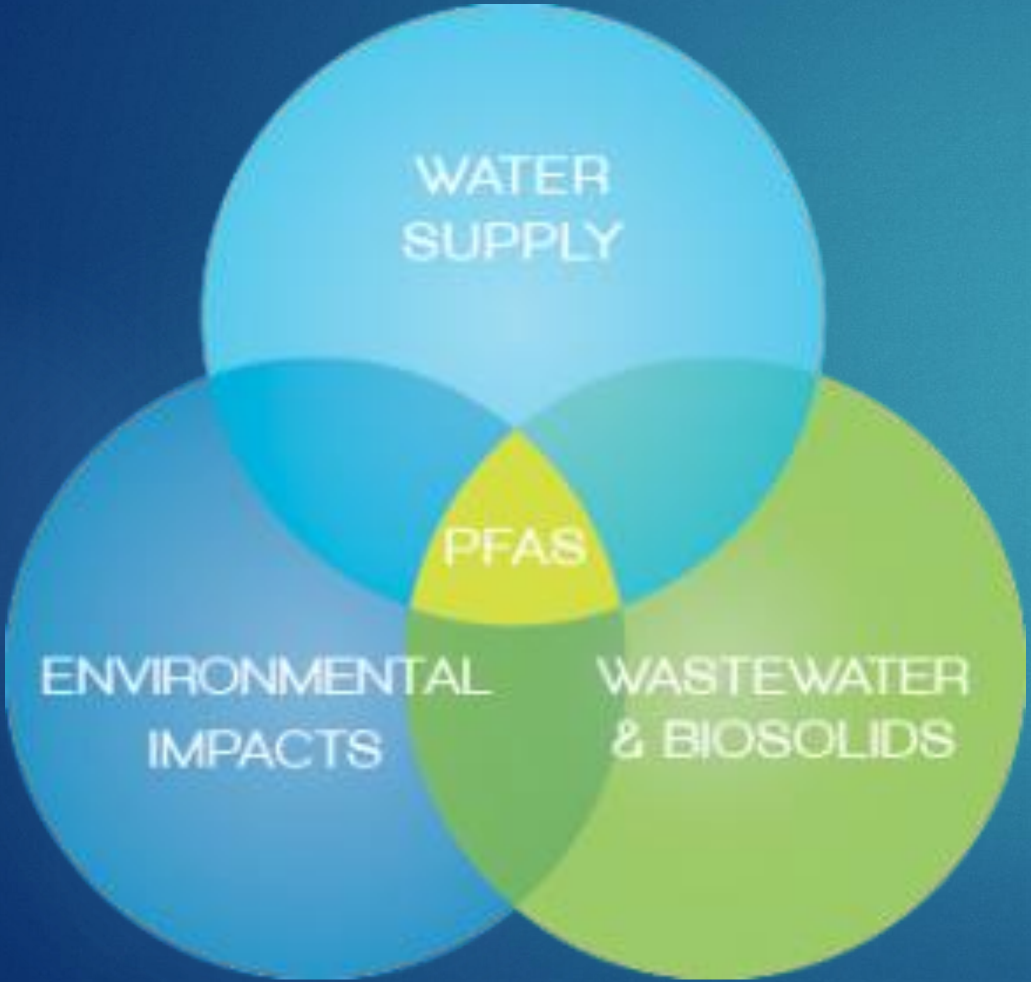
Classes of compounds identified as Emerging Contaminants

- ✓ Pharmaceuticals
- ✓ Personal Care Products
- ✓ Pesticides and Herbicides
- ✓ Halogenated and Non-halogenated Compounds
- ✓ Synthetic Fragrances
- ✓ Phthalates
- ✓ Bisphenol A *(used in the manufacture of epoxy resins and other polymers)*
- ✓ Phytoestrogens
- ✓ Nanomaterials

The problem of Emerging Contaminants is the *lack of knowledge* of their impact in the long-term effect on human health and the environment.

Antibiotics manufacturers often *illegally* discharge wastewater into their neighboring environment, causing further contamination to groundwater, waterways, soil and local communities.

EMERGING CONTAMINANTS: PFAS - THE FOREVER CHEMICAL



Utilities across the United States are being impacted by Emerging Contaminants such a PFAS *above* the USEPA health advisory levels and individual state regulatory standards.

Unregulated Contaminant Monitoring Rule (UCMR)

EPA uses the Unregulated Contaminant Monitoring Rule (UCMR) to collect data for contaminants that are suspected to be present in drinking water that currently do not have health-based standards set under the Safe Drinking Water Act (SDWA).

Unregulated Contaminant Monitoring Rule (UCMR)

The SDWA Amendments of 1996 provide for:
Monitoring no more than 30 contaminants every five years
Monitoring large systems and a representative sample of small public water systems serving less than or equal to 10,000 people
Storing analytical results in a National Contaminant Occurrence Database (NCOD).

<u>Unregulated Contaminant Monitoring Rule (UCMR)</u>

Data is collected through UCMR to support the determination of whether to regulate particular contaminants in the interest of protecting public health. EPA’s selection of contaminants for a particular UCMR cycle is largely based on a review of the Contaminant Candidate List (CCL).
The UCMR program was developed in coordination with the CCL.

Unregulated Contaminant Monitoring Rule (UCMR)

The CCL is a list of contaminants that:
Are not regulated by the National Primary Drinking Water Regulations
Are known or anticipated to occur at public water systems
May warrant regulation under the SDWA

<u>Unregulated Contaminant Monitoring Rule (UCMR)</u>

EPA pays for the analysis of all samples from systems serving 10,000 or fewer people.

EPA coordinates an approval program for laboratories that wish to analyze public water system samples.

How does EPA select the contaminants for UCMR?

EPA reviews contaminants that have been evaluated through existing prioritization processes, including previous UCMR contaminants and the CCL.
Additional contaminants may be identified based on current research on occurrence and health effect risk factors.

UCMR 3

UCMR 3 monitoring occurred between January 2013 and December 2015 and included two to four quarterly samples at mostly large water systems throughout the country.
UCMR 3 required monitoring for 30 contaminants (28 chemicals and two viruses).

UCMR 5

The fifth Unregulated Contaminant Monitoring Rule (UCMR 5) was signed on January 14, 2021.
UCMR 5 requires sample collection for 30 chemical contaminants between 2023 and 2025.

This action provides EPA, states, and communities with scientifically valid data on the national occurrence of these contaminants in drinking water.

UCMR 5

Small systems less than 3000
800 systems randomly selected

Small systems 3300 to 10,000
All Drinking Water systems participating

Large systems 10,001 and larger
All Drinking Water systems participating

UCMR 5

What contaminants are being proposed for UCMR 5?

29 different PFAS chemicals
1 Metal - Lithium

UCMR 5

- Who will help pay for the testing?
- The $10 billion to help address PFAS contamination is split through three programs:

  $5 billion through the EPA's Assistance to Small and Disadvantaged Communities Program and State Response to Contaminants program to address emerging contaminants

  $4 billion through the Drinking Water State Revolving Fund for emerging contaminants with a focus on PFAS

  $1 billion through the Clean Water State Revolving Fund to address emerging contaminants.

In 1938, DuPont was conducting research to find new chemicals that could be used as refrigerants when its chemists stumbled upon an unusual coating in one of their test chambers.

Testing revealed that the new substance, PTFE (polytetrafluoroethylene), was chemically very stable and had a remarkable ability to repel water and oil.

This was the first PFAS ever invented, and it was soon put to good use in the Manhattan Project because it could resist corrosion from fluorine in the gaseous diffusion process used to enrich uranium.

After World War II, Dupont marketed this substance in a very successful product it called Teflon that was used in non-stick cookware and water and stain resistant fabrics. The discovery of Teflon is often cited as an example of serendipity, or accidental discovery.

The acronym "PFAS" stands for *Per* - and *Poly* FluoroAlkyl Substances.

- There is no universally accepted definition of PFAS.
- Manufactured by chemical companies since the 1940s, PFAS molecules are made up of a chain of carbon and fluorine atoms linked together, where the carbon-fluorine bond is one of the strongest bonds in existence.

- PFAS molecules have a dual nature. They are both hydrophobic and hydrophilic, which makes it difficult to predict how they will move in the environment.

- "They're weird. And that's what makes them so attractive for industrial applications. This part repels water and this part repels oil, and that's why we use them so much. But it makes predicting their fate challenging, because they don't always behave the way we think they ought to."

~ University of Wisconsin aquatic chemist Dr. Christy Remucal

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- We are exposed to PFAS through the air, dust, drinking water, food, and products (such as certain nonstick pans, take-out food containers and more) made with these chemicals. Since PFAS don't break down easily, they have persisted for decades, even those that have been phased out of production.

- PFAS are commonly found in water, soil, and bio-solids, so they can easily contaminate our crops, chicken, livestock, and other animals on farms that produce our meat, dairy, grains, vegetables, fruits, and eggs.

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PFAS HEALTH CONCERNS

The most consistent findings are increased cholesterol levels among exposed populations, with more limited findings related to:

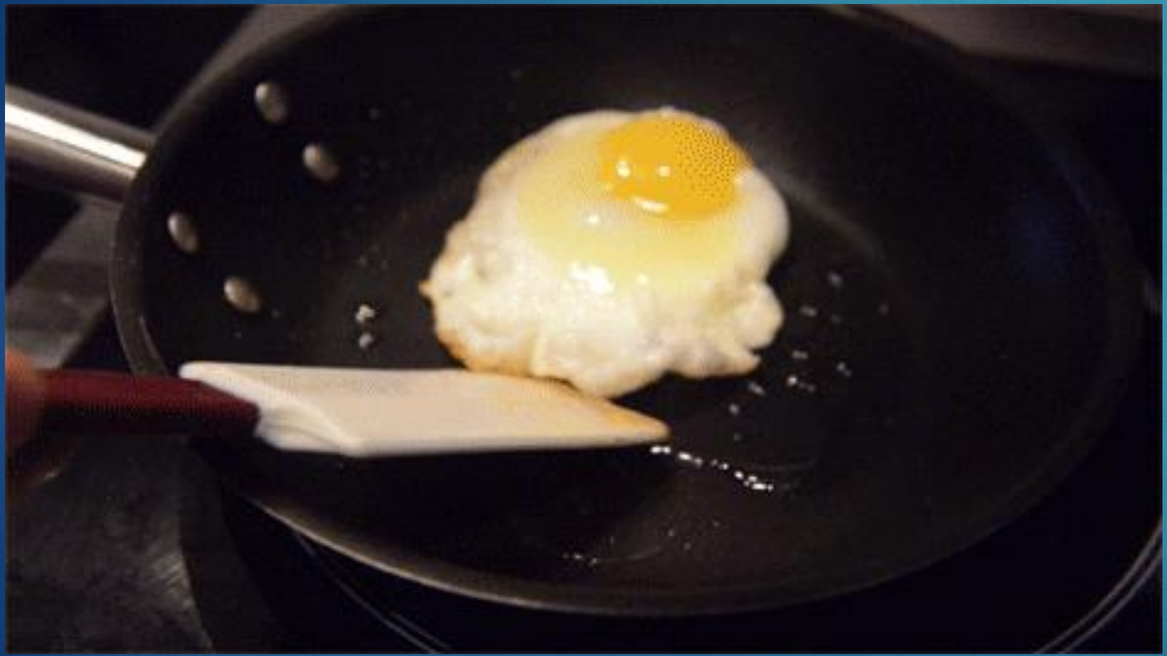
- *Pregnancy-induced hypertension or pre-eclampsia*
- *Decrease fertility*
- *Low infant birth weights*
- *Effects on the immune system*
- *Cancer (for PFOA) – including testicular & kidney cancer*
- *Thyroid hormone disruption*
- *Ulcerative colitis*
- *Liver damage*
- *Immune system issues*
- *Growth, learning & behavior issues*
- *Increase in asthma diagnosis*

A recent inventory identifying more than 4,700 PFAS that could have been, or may be, on the global market, and the uses of each of these PFAS may not be known.

Polling Question

Uses of PFAS

Fluoropolymers are commonly used in the manufacture of



- Outdoor Gear
- Clothing
- Housewares

PFAS is frequently used in:

- Oil/Water Repellent Clothing
- Stain Release Finishing
- Fabric Treatment Coatings

PFAS is also used in construction.

- Sealants
- Caulks
- Varnishes
- Dyes
- Stains
- Adhesives
- Surface treatment agent
- Laminates
- Additives in paints (low- and no-VOC latex paints)

PFAS are even used in

- Some Class B Fire Suppression Foam
- Air Craft Fire fighting foam (AFFF)
- Vapor Suppression for Flammable Liquids
  (for example, gasoline storage)

Since the 1950s, many products commonly used by consumers and industry have been manufactured with or from PFAS, as the unique physical and chemical properties of PFAS impart oil, water, stain, and soil repellency, chemical and thermal stability, and/or friction reduction to a range of products.

These products have applications in many industries, including the aerospace, semiconductor, medical, automotive, construction, electronics, and aviation industries, as well as in consumer products, such as carpets, clothing, furniture, outdoor equipment, food packaging, and firefighting applications.

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Scientists are ramping up research on the possible health effects of a large group of *common but <u>little understood chemicals</u>* used in

- water resistant clothing
- stain-resistant furniture
- nonstick cookware
- and many other consumer products

- PFAS are a complex family of manmade fluorinated organic compounds.
- It has been estimated that the PFAS family may include approximately 5,000 to 10,000 chemicals.

SCOTCHGARD
PROTECTOR
3M
For Leather

GORE-TEX

SIMONIZ

Teflon

STAINMASTER

DUPONT
Kevlar

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PFAS is EVERYWHERE

- Food contact paper and cardboard packaging
- Clothing and carpets
- Outdoor textiles and sporting equipment
- Ski and snowboard waxes
- Non-stick cookware
- Cleaning agents and fabric softeners
- Polishes and waxes, and latex paints
- Pesticides and herbicides
- Hydraulic fluids
- Windshield wipers
- Paints, varnishes, dyes, and inks
- Adhesives
- Medical products
- Personal care products (for example, shampoo, hair conditioners, sunscreen, cosmetics, toothpaste, dental floss)

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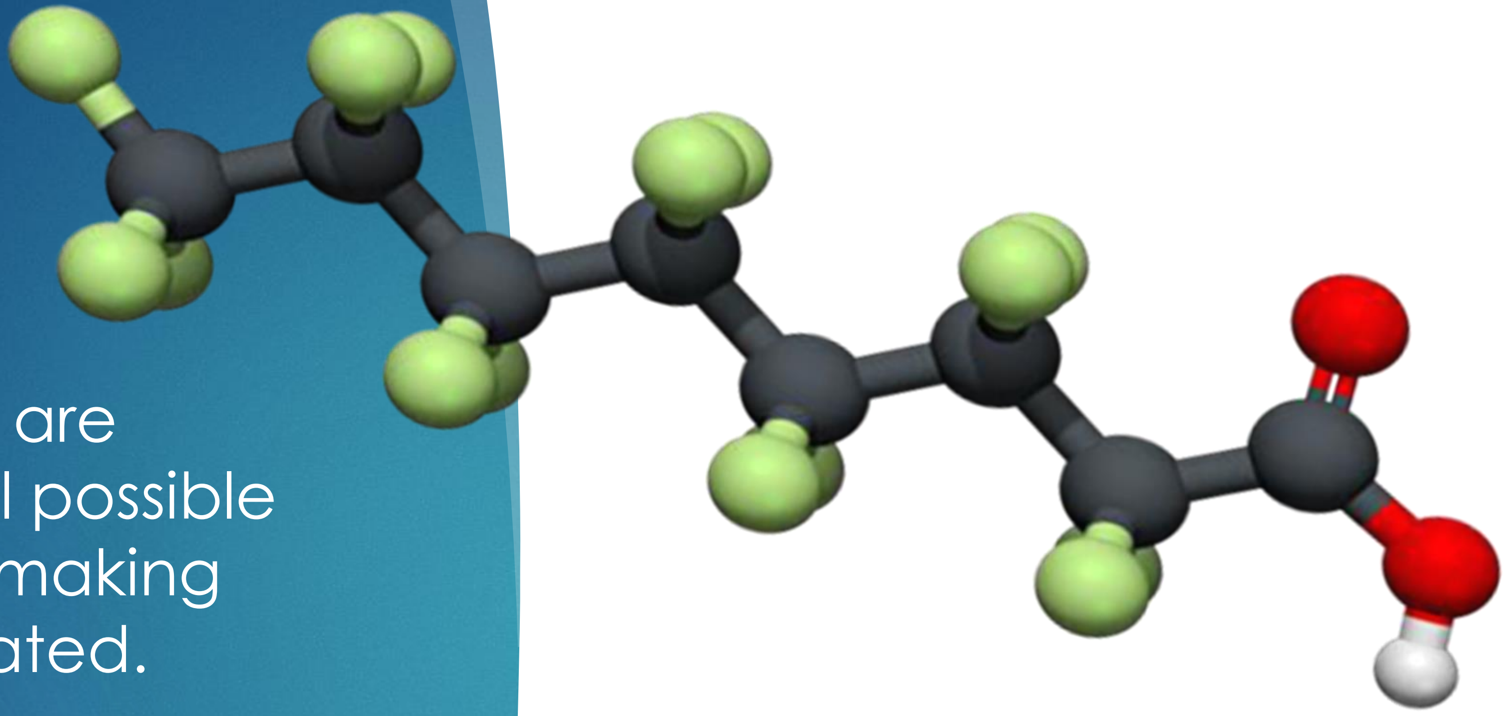
Properties of PFAS

PFAS are Extremely Stable

- Carbon-fluorine bonds are one of the strongest single bonds in chemistry
- Makes PFAS are very hard to destroy
- Remains stable at high heat



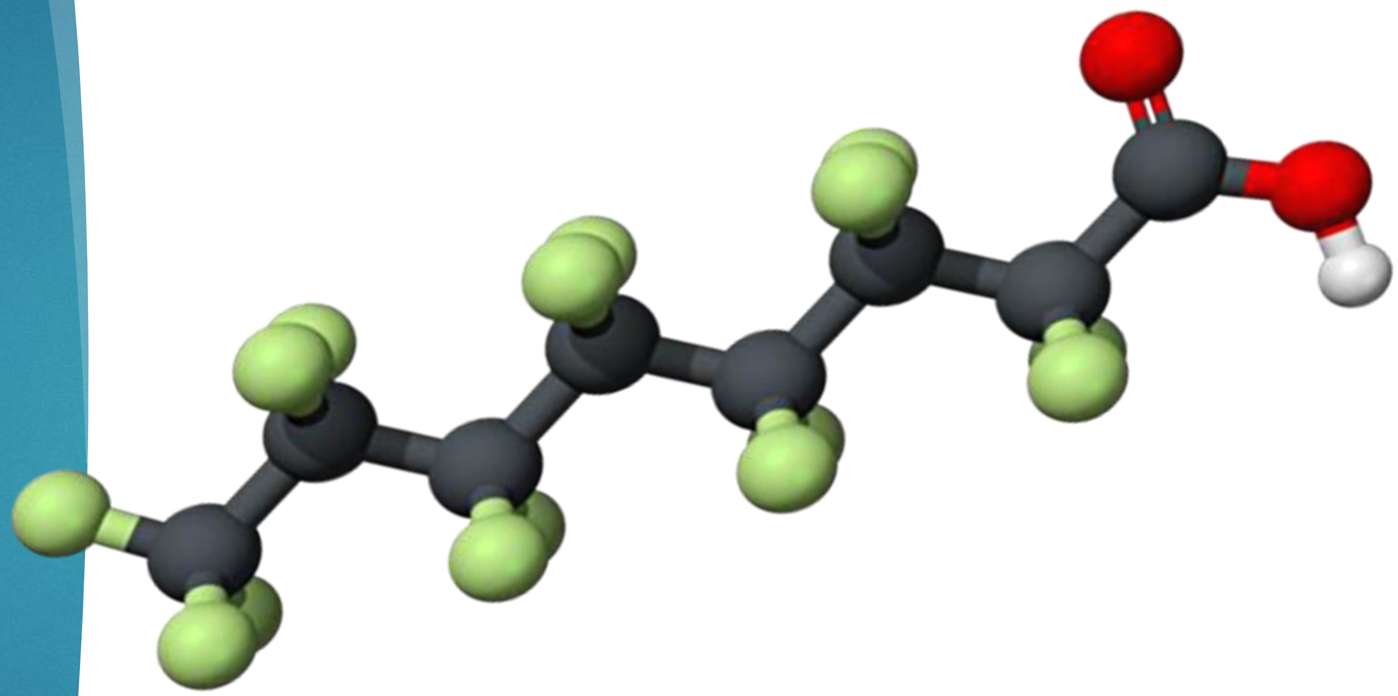
- Fluorine atoms are attached to all possible bonding sites, making this ***per-***fluorinated.

- If some of the fluorine atoms were replaced by other atoms (such as oxygen or hydrogen), it would be ***poly-***fluorinated.

This 3D model of a PFO**A** (perfluorooctanoic **acid**) molecule.

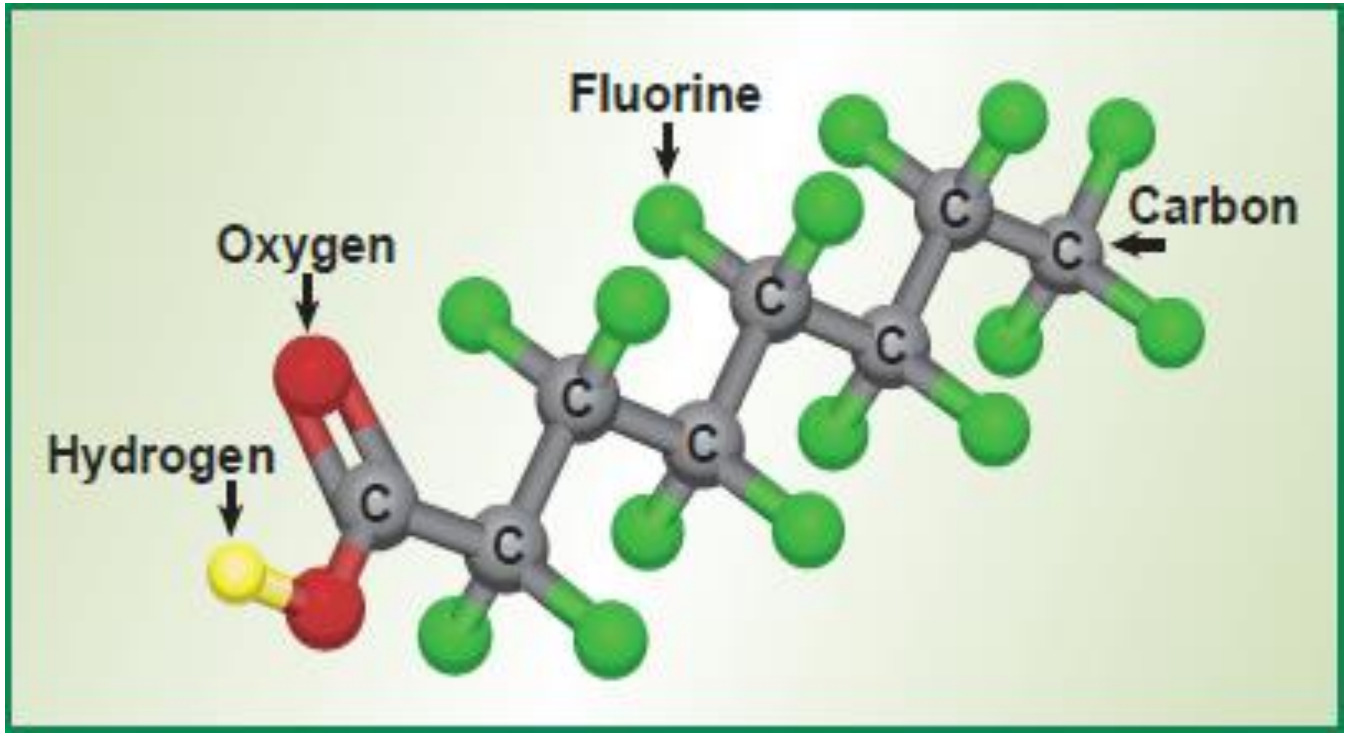
This is the acid form of PFOS.

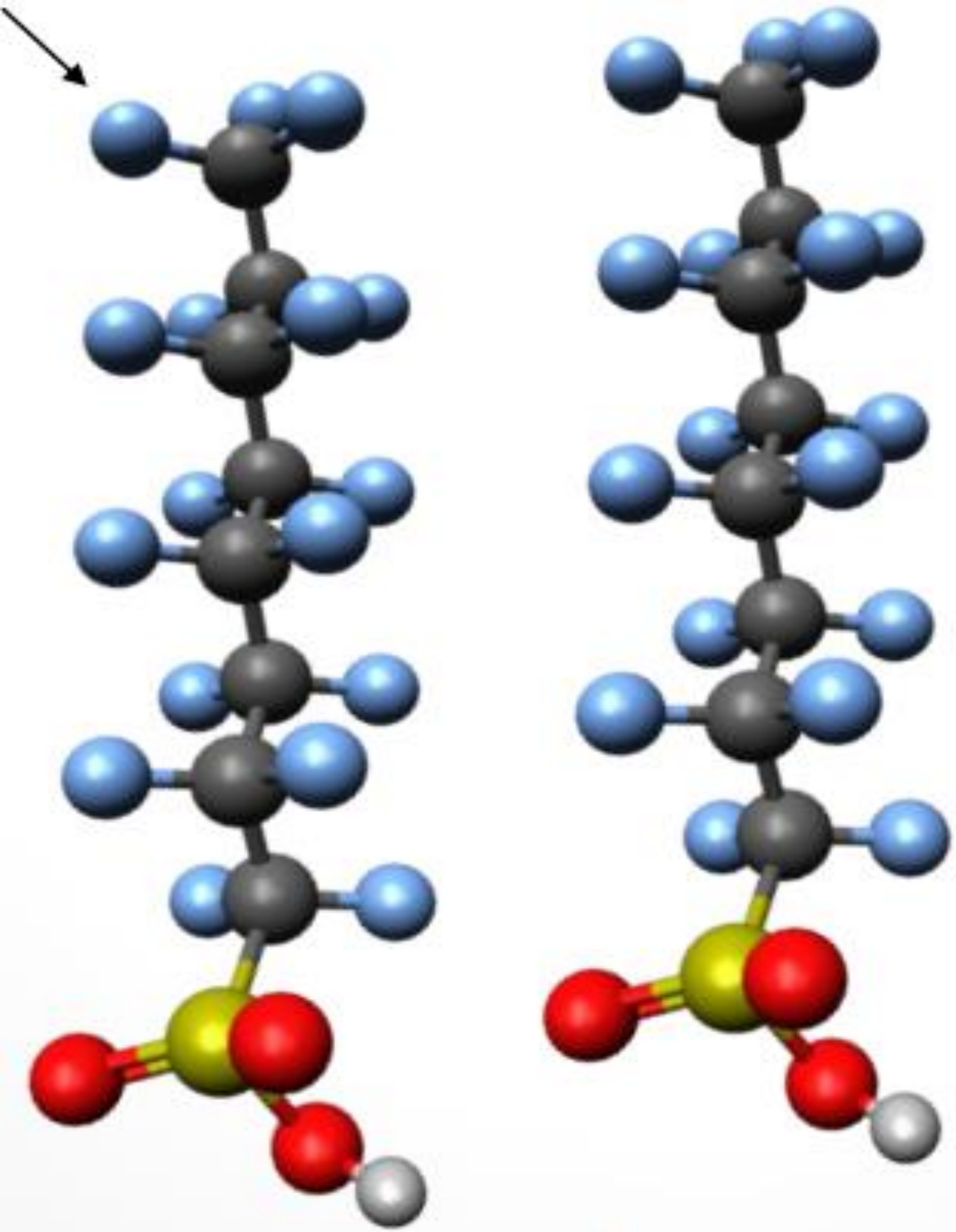
- Gray spheres represent *carbon atoms* linked together in a chain; there are eight of them, so "octane" is used in the name.
- Green spheres represent *fluorine atoms* bonded to carbon atoms.
- Red spheres represent *oxygen atoms.*



- Without the hydrogen (in yellow), the "head end" takes on a *negative* charge and can bond to things through *electrostatic* attraction.

- The fluorine "tail end" (green) is strong and stable, giving it fat and water repelling properties, but also making it *persistent in the environment*.



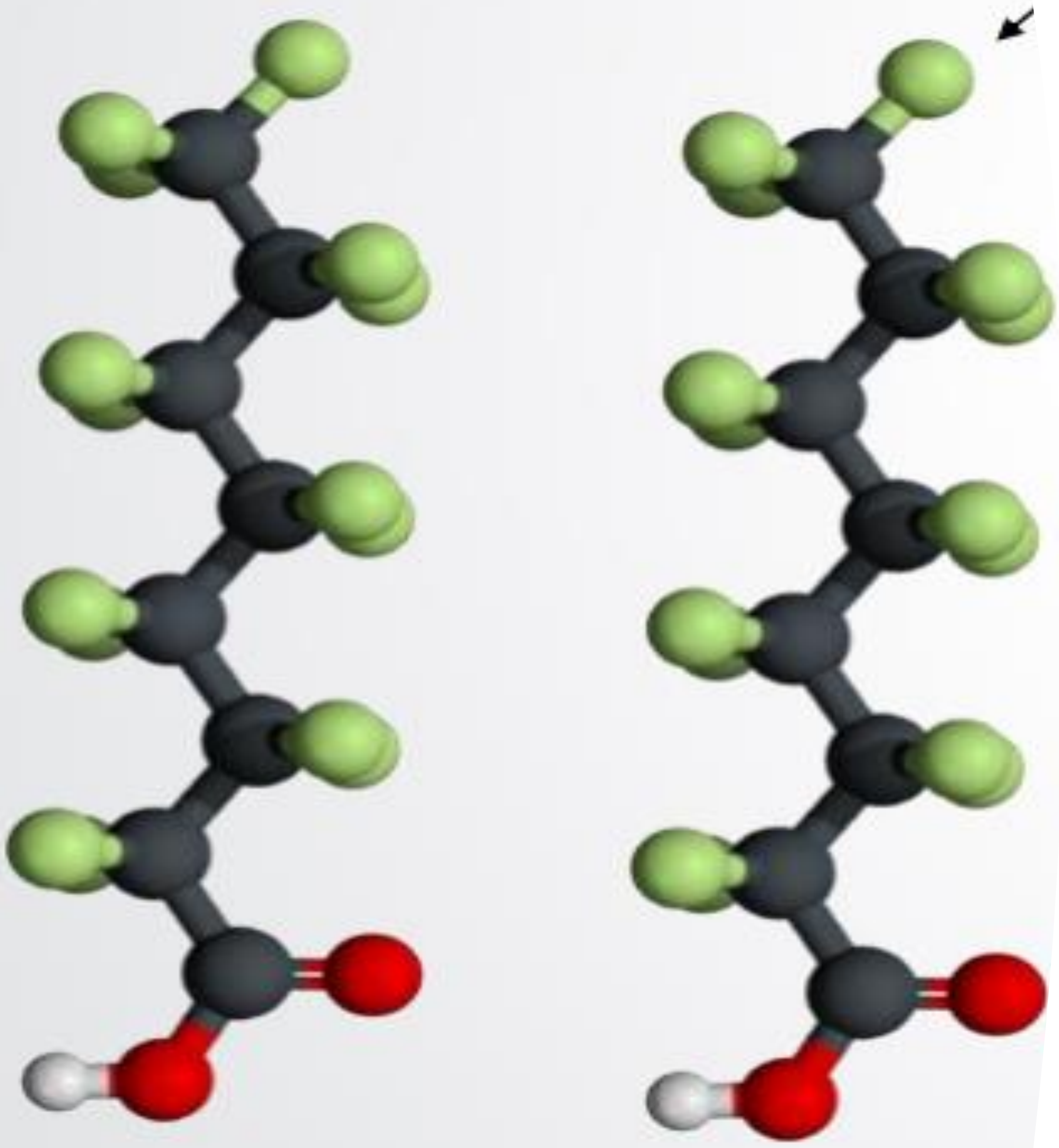


Perfluorooctanesulfonic acid (PFOS)

PFOS stands for Perfluorooctane sulfonate.

PFOS refers to the parent sulfonic acid and its various salts of *per-fluoro-octan-sulfonate*. These are all colorless or white, water-soluble solids.

It was added to Annex B of the Stockholm Convention on Persistent Organic Pollutants in May 2009.

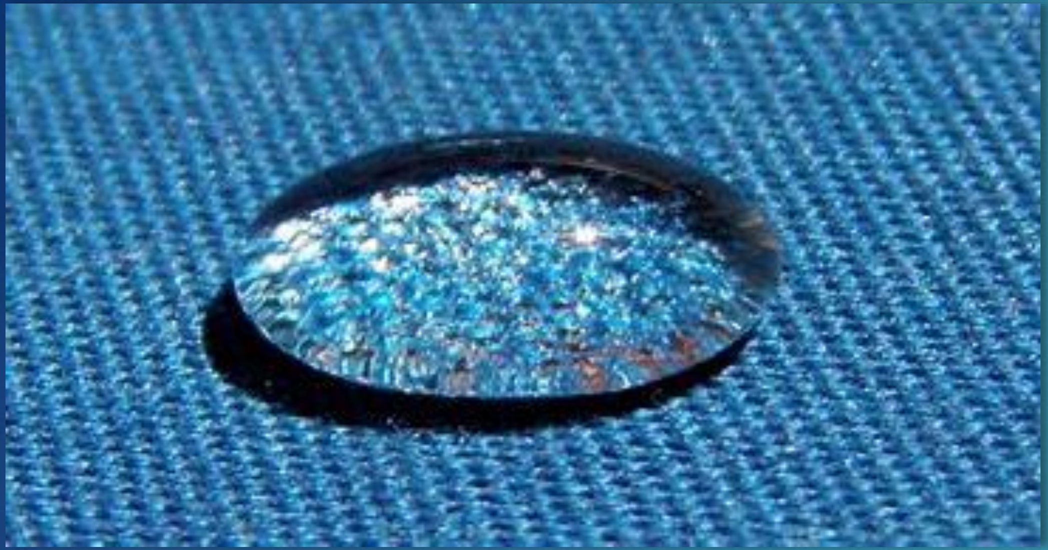


Perfluorooctanoic acid (PFOA)

The PFOA stands for **Perfluorooctanoic acid.**

PFOA has the chemical formula $C_8HF_{15}O_2$, a melting point of 40 to 50 degrees Celsius and a boiling point of 189 degrees Celsius. Moreover, the chemical has a molar mass of 414.07 grams per mol, and a density of 1.8 grams per cubic centimeter.

PFOA identifies as Chemical Abstract Service Number 335-67-1, and exists as a white power and wax. And unlike PFOS, perfluorooctanoic acid becomes water-soluble at a concentration of 0.0095 milligrams per liter, at a temperature of 25 degrees Celsius.



The unique physical and chemical properties of PFAS include:

- Oil and Water Repellency
- Temperature Resistance
- Friction Reduction

Therefore, it is an extremely versatile chemical for numerous products.

Discussion

What kinds of these products have you personally used in the last year?

And in the last week?

How does that make you feel?

The Environmental Issue

Not all types and uses of PFAS result in the same level of environmental impact and exposure.

When considering potential environmental impacts from PFAS, it is critical to be as specific as possible not only about the particular PFAS involved, but *also where and how they are released to the environment*.

- Scientific, regulatory, and public concerns have emerged about potential health and environmental impacts associated with chemical production, product manufacture and use, and disposal of PFAS-containing wastes.

PFAS have been released in the environment since the 1950s and are now present worldwide, with the ocean considered the final sink for these contaminants.

Even though some functional groups (i.e., carbon-fluorine bonds) of PFAS are very stable, many PFAS breakdown and reform into other PFAS in the environment, presenting challenges for monitoring their presence, and modeling their transport in aquatic systems.

Environmental concerns have led to efforts to reduce the use of or replace certain PFAS, such as certain long-chain perfluoroalkyl carboxylates, long-chain per-fluoroalkane sulfonates and their precursors.

The Environmental Issue

Due to the solubility and persistence of many PFAS, environmental release apparatuses associated with these facilities include:

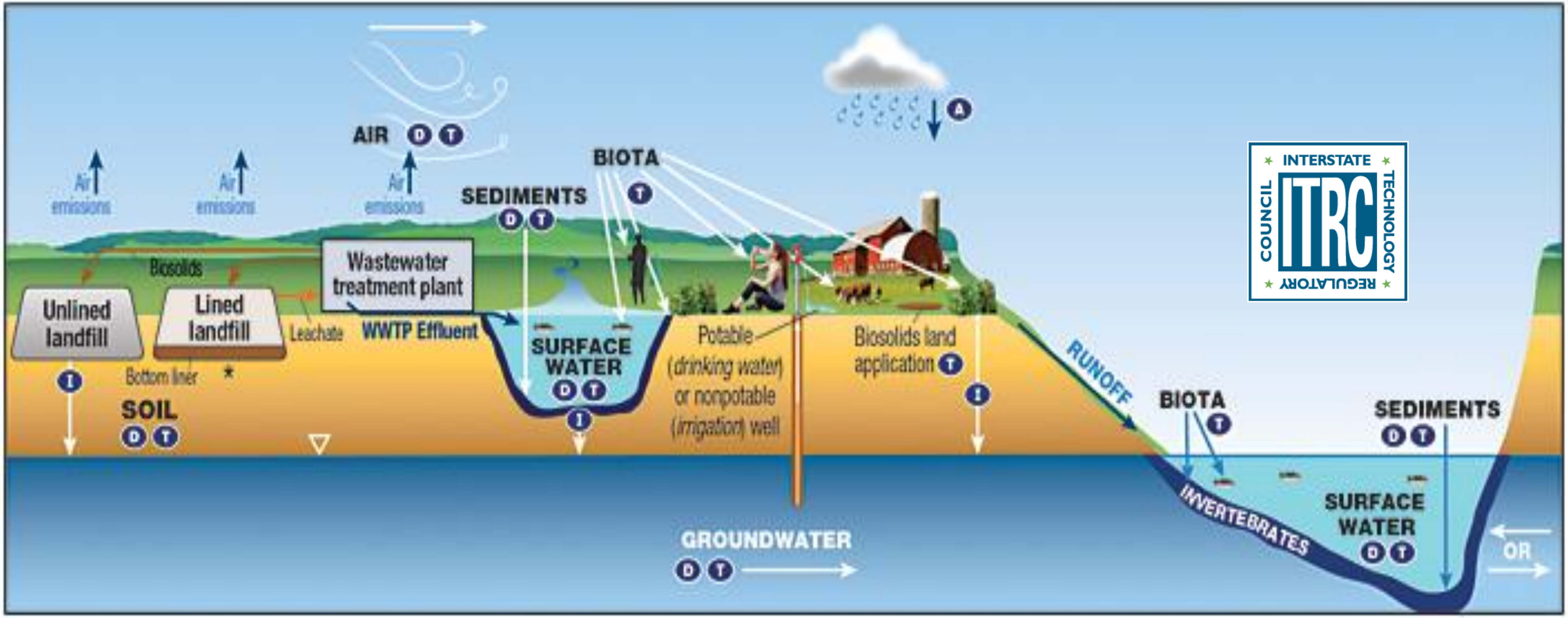
- Air Dispersion
- Spills
- Disposal of Manufacturing Wastes and Wastewaters

Sometimes the intended use of the PFAS product (for example, firefighting foams) requires direct release to the environment.

PFAS from a host of sources also may be found in wastewater treatment plant effluent and sludges, creating secondary release sources.

The volume, concentration, and mixture of PFAS released to the environment varies based on the source (process, material, or product), release mechanisms, and environmental controls.

Potential Release Scenarios at Waste Management Facilities



*Leachate release from lined landfills could occur in the event of a liner leak

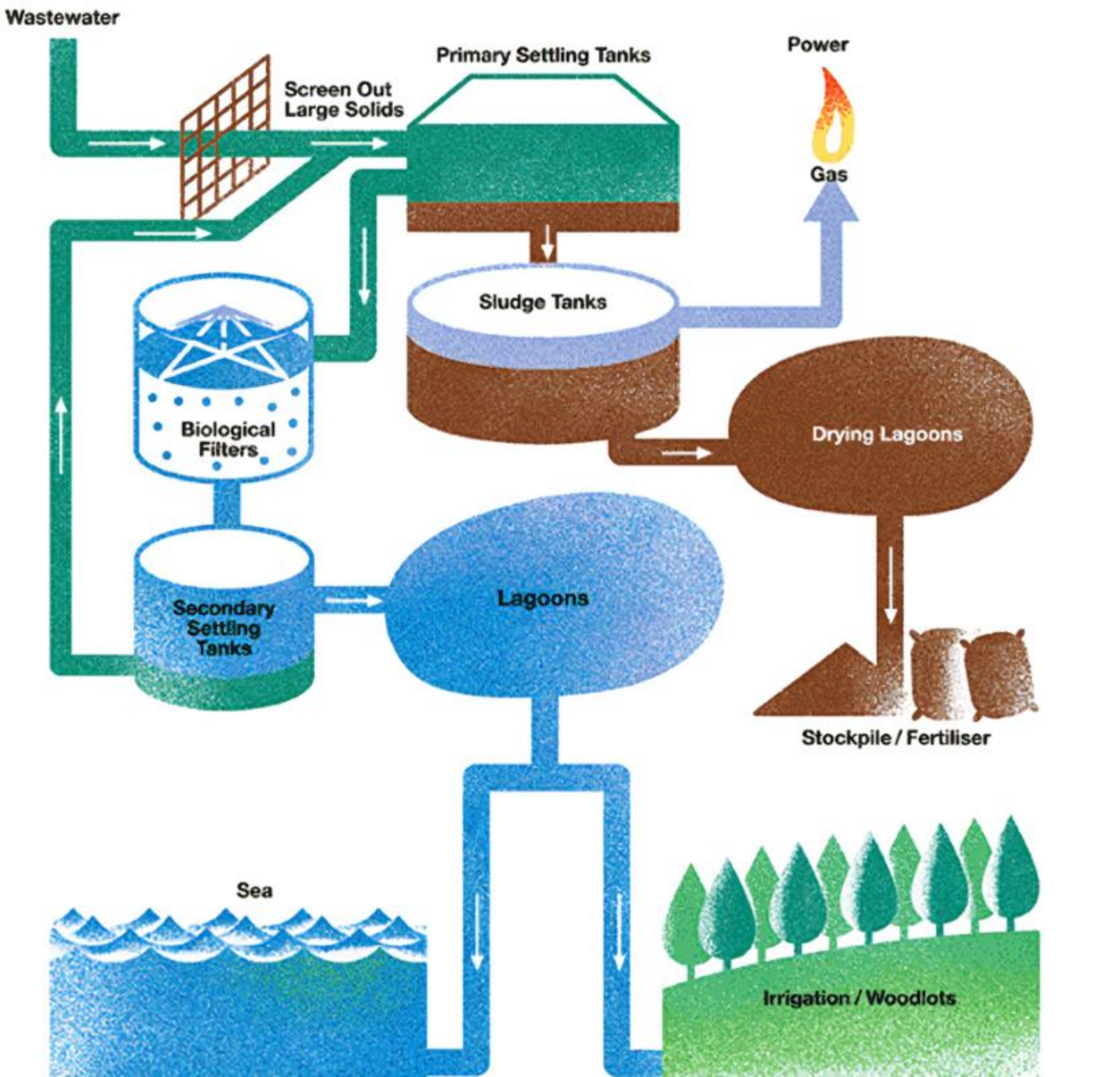
KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

Polling Question

So NOW what?

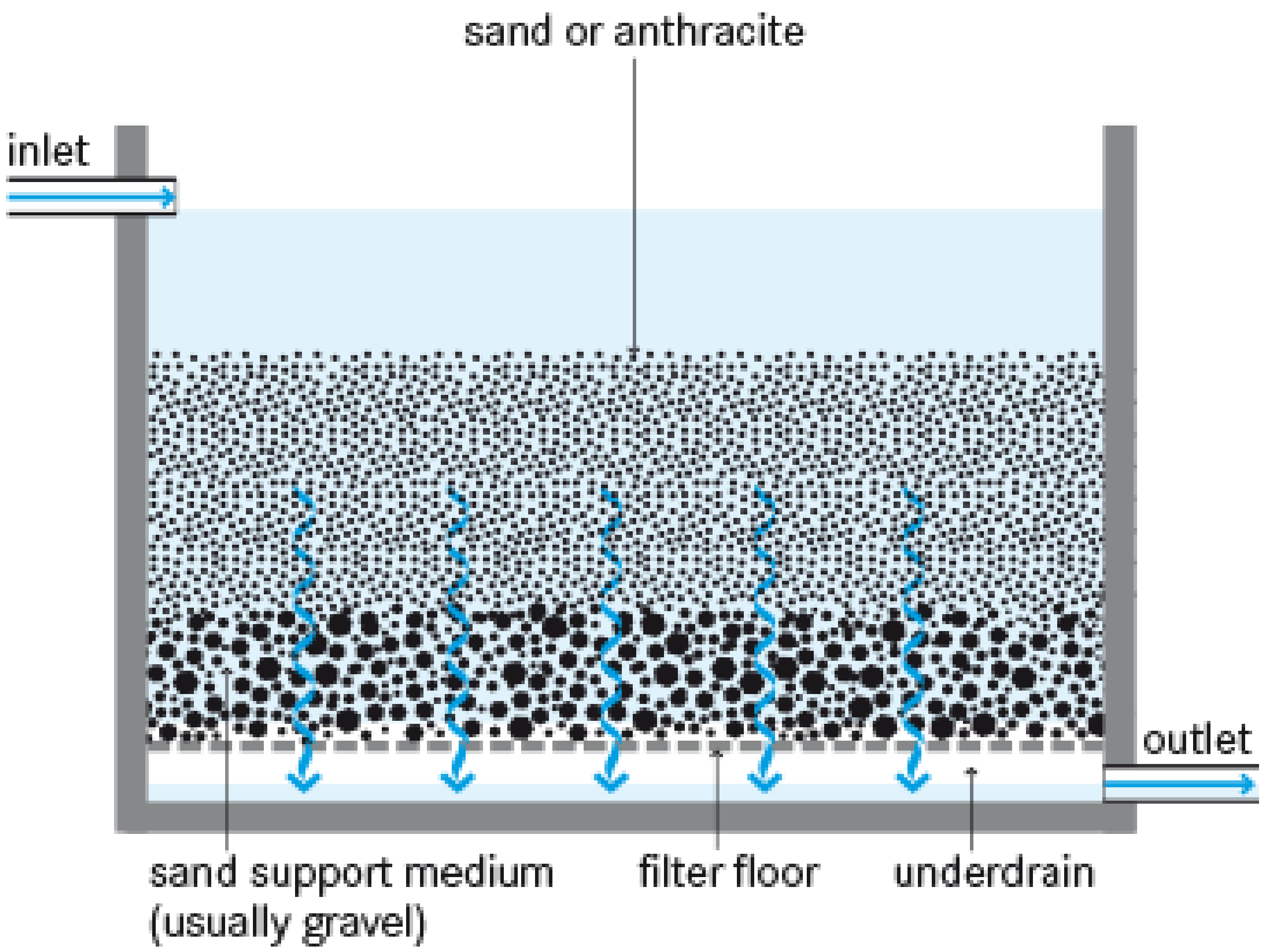
Treatment Technologies

Conventional WWTPs usually based on biological processes, are unable to fully remove the emerging contaminants from wastewater.



Effluent from the wastewater treatment facility is released into local waterways where it potentially enters the municipal water supply.

Tertiary treatment technologies are the most promising options for reducing Emerging Contaminants.



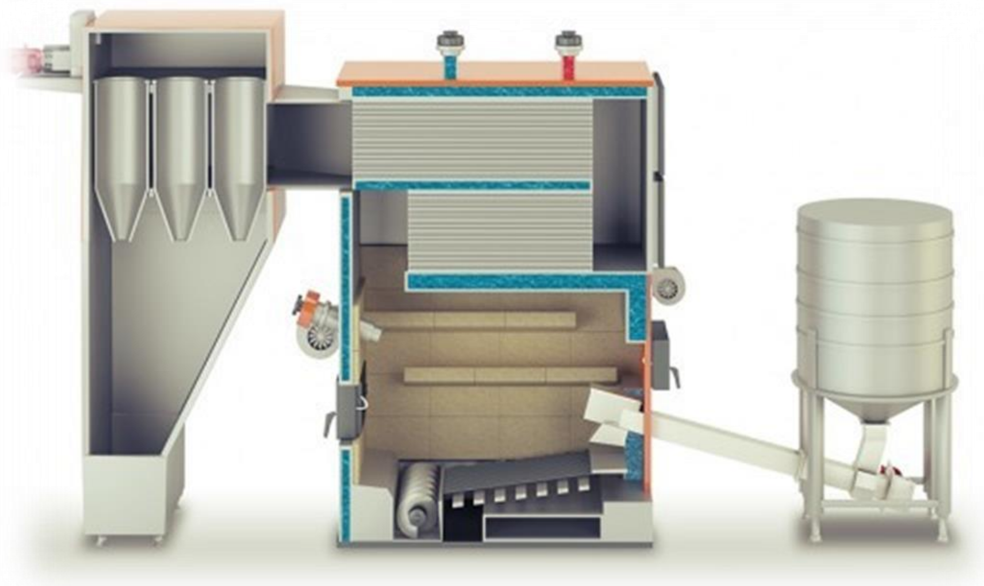
tertiary filtration (e.g. depth filtration)

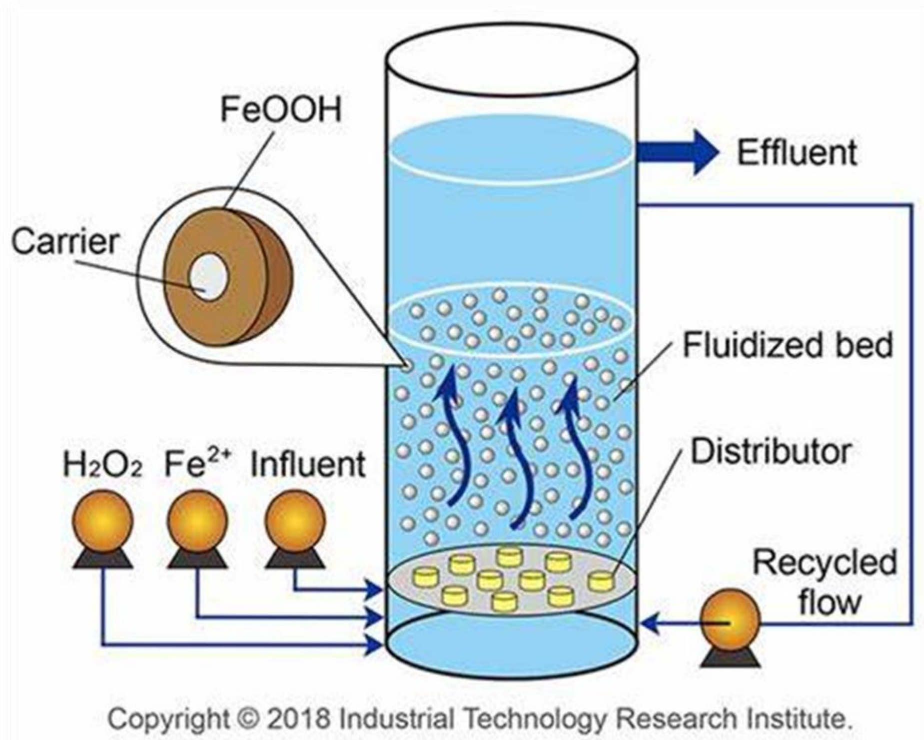
Future research must concentrate on developing sustainable and innovative treatment processes to increase the removal efficiency of emerging contaminants in WWTPs.

Effectively removing PFAS in drinking water requires the same technologies used to remove them from wastewater, which is an expensive proposition.

Even aggressive technologies such as thermal treatment and chemical oxidation require extreme conditions beyond typical practices.

Extreme temperatures, high chemical doses, extreme pH need to be achieved to be effective *or partially effective* in destroying PFAS.

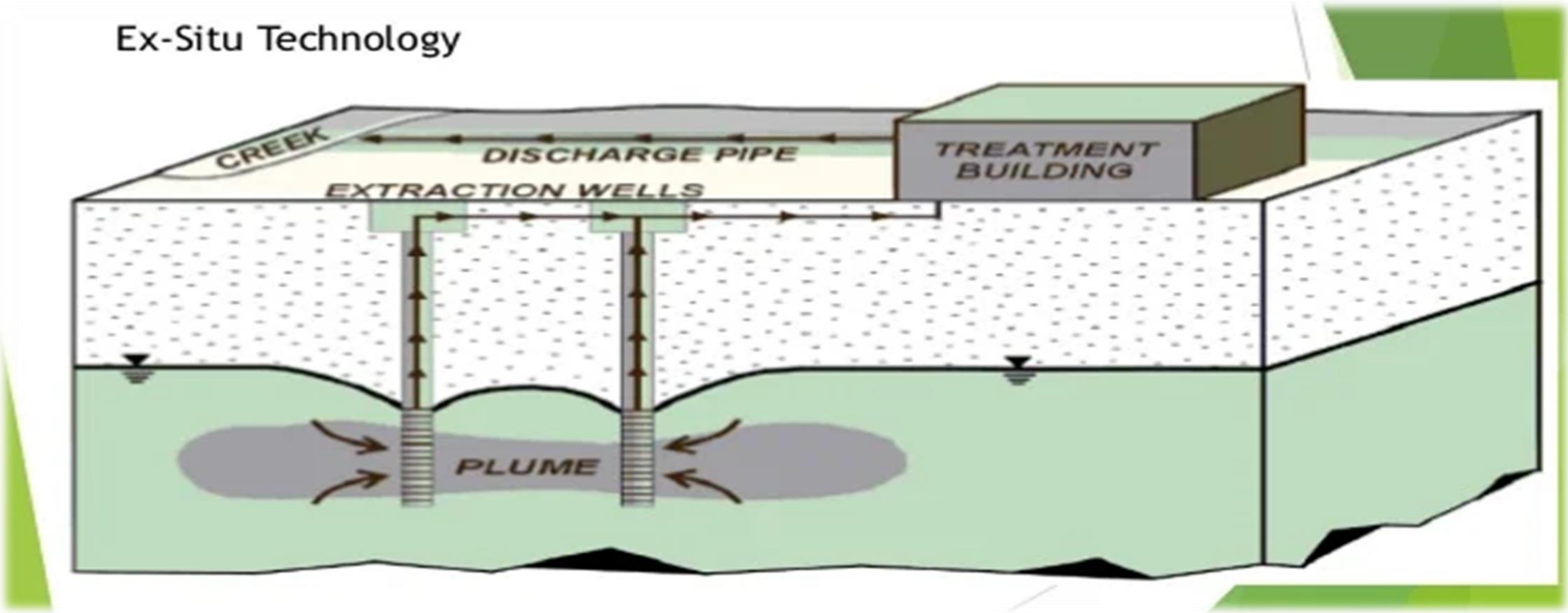




A range of unproven technologies exist for treatment of either liquids or solids that may be performed either in situ or ex situ.

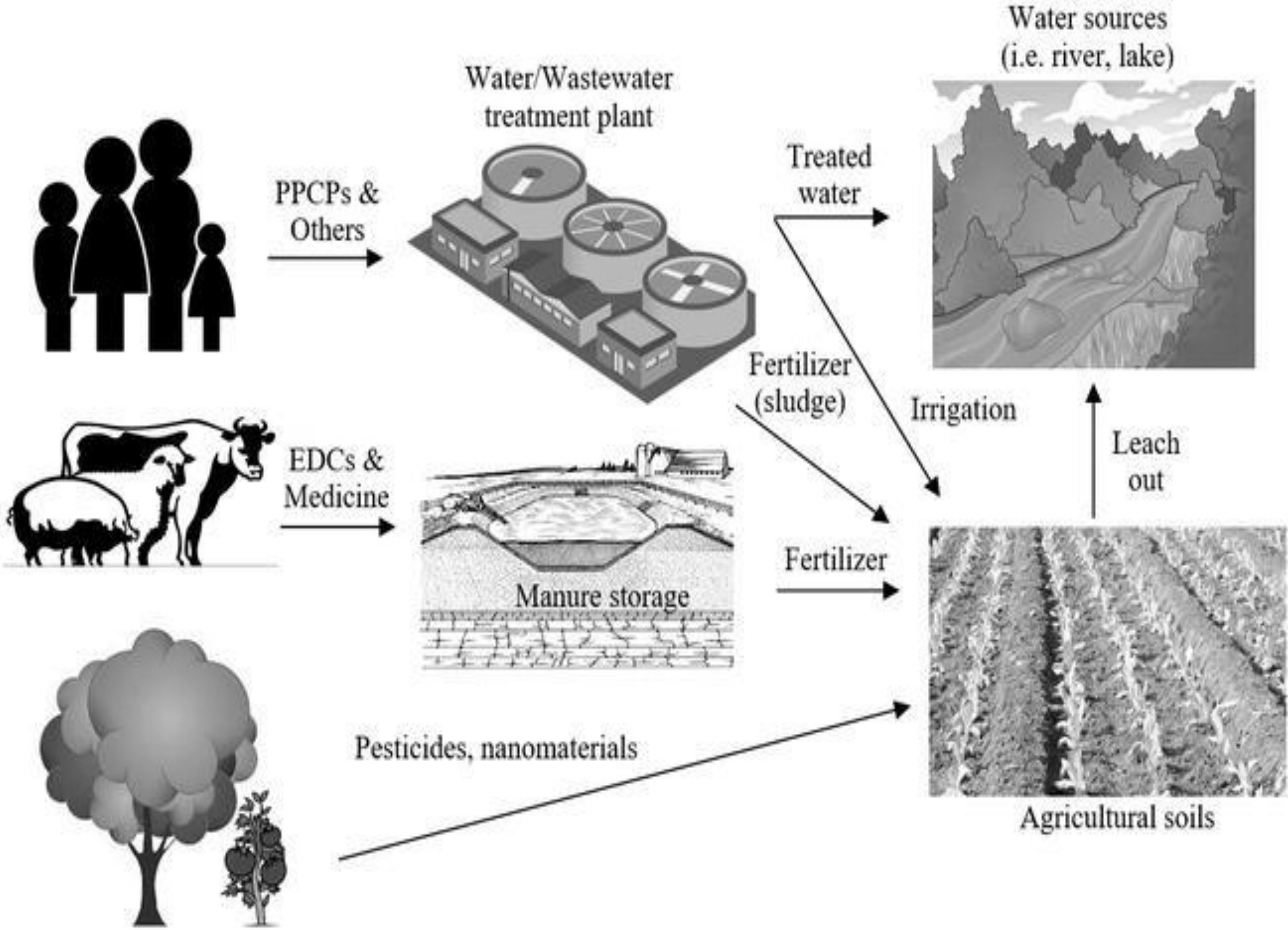
Full-scale treatment of PFAS-impacted liquids or solids is currently limited to sequestration technologies that remove or bind PFAS but do not destroy them.

The most *demonstrated* technologies for treating PFAS in liquids are limited to the use of ex situ technologies.



Sorption using granular activated carbon and ion exchange media has been proven effective at full scale.

Transformation or destruction technologies, including bioremediation, chemical oxidation, chemical reduction, and thermal technologies, are currently being tested.



Treatment of Emerging Contaminants in the Wastewater Treatment Plant

Treatment Overview

- Activated Carbon (Granulated or Powdered)
- Ion Exchange Resin (IX)
- Reverse Osmosis (RO) and Nanofiltration (NF)
- Advanced Oxidation
  - Ozone
  - Catalyzed Hydrogen Peroxide
- Biosolids Removal

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Activated Carbon (Granulated or Powdered)

Granular activated carbon (GAC) Pros	Cons
▪ Reduce PFAS to ng/L level for drinking water ▪ Effective for long-chain PFAS removal ▪ Relatively inexpensive and simple maintenance ▪ Good PFAS removal efficiency	▪ Quick PFAS (short-chain PFAS in particular) breakthrough and frequent filter replacement due to weak interactions between PFAS and carbon ▪ Not cost effective for waters containing other organic compounds since GAC is non-selective and will be over-loaded by other organics ▪ Does not remove inorganics ▪ GAC is a very expensive consumable. It can be manual intensive GAC to replace, or energy intensive regeneration (often off-site via extreme temperature vaporization) ▪ Must be regularly cleaned or replaced with new Activated Carbon ▪ PFOA and PFOS removal are not consistently above 90%

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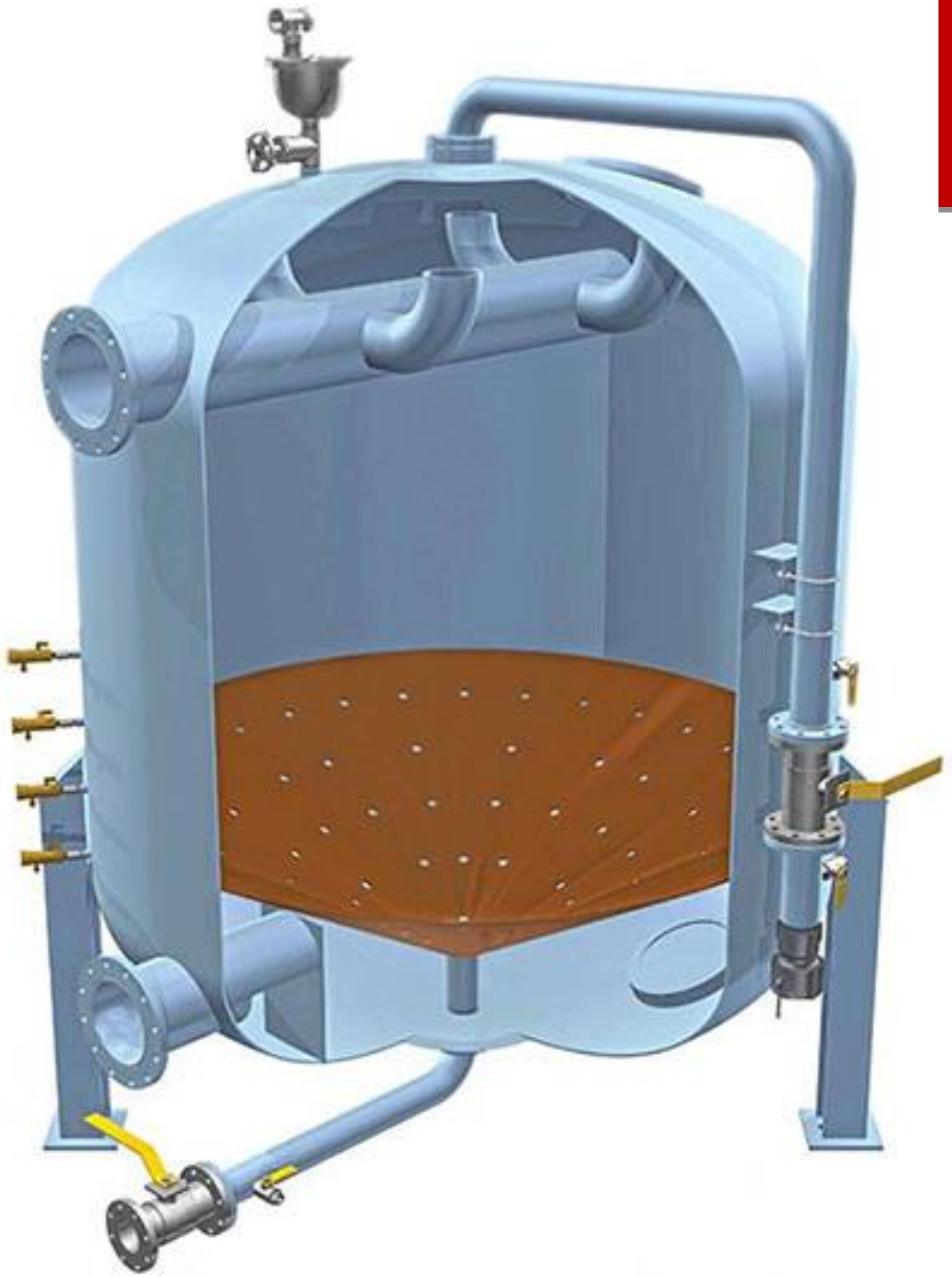
Activated Carbon

- Removes PFAS via sorption
- Must be regularly cleaned or replaced with new Activated Carbon
- 40-99% PFOA removal, 18-98% PFOS removal, about 90-99% removal of other PFAS

Typical pressure vessel with conical underdrain for Granular Activated Carbon



Granular Activated Carbon (GAC) Facts:

- Has received the most research for PFAS removal, so far, and is most effective as a flow-through filter after particulates are already removed.
- Works well on longer-chain PFAS, such as PFOA and PFOS.
- Can remove PFAS along with a range of other contaminants at the same time.
- Are normally heated to destroy PFAS (usually offsite) and to restore the media's adsorptive capacity.
- Is a very effective solution, but its success will depend on the type of carbon used, the Empty Bed contact time (EBCT), flow rate, the nature of the PFAS, and whether other contaminants are in the water.

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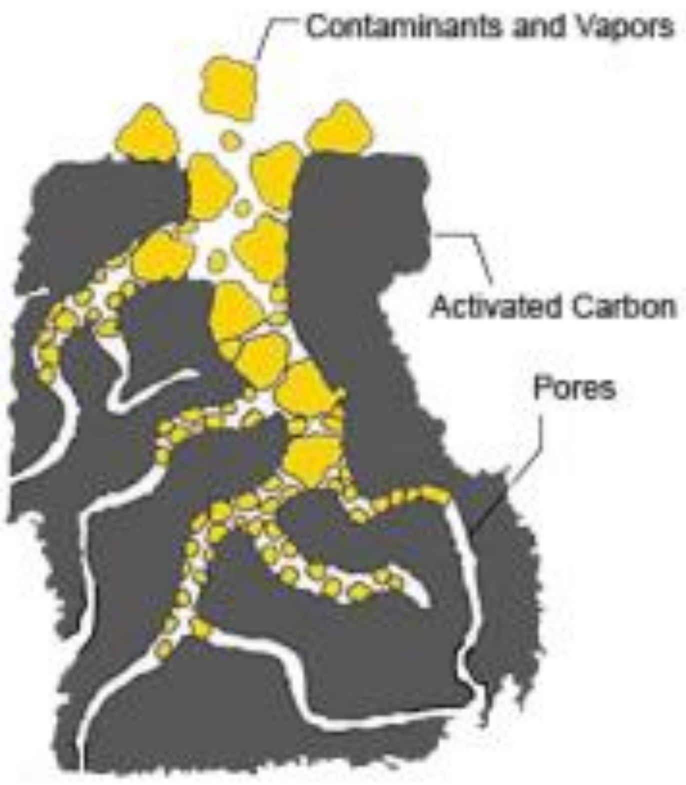
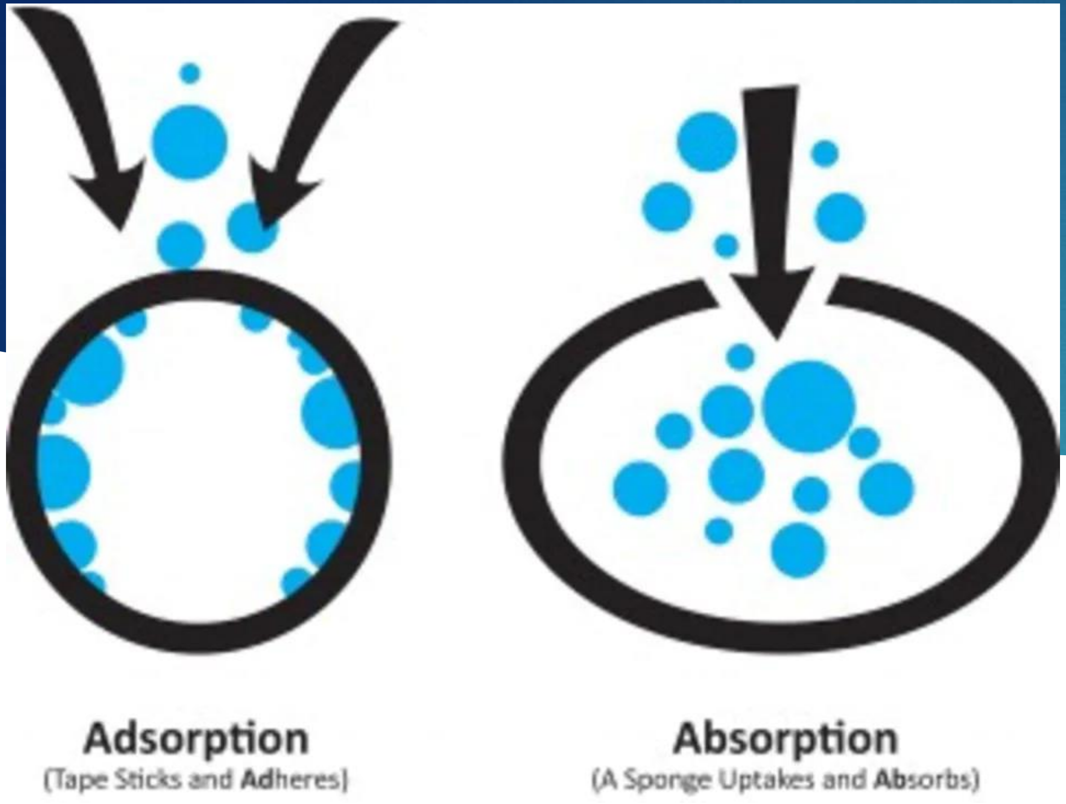
The versatility of carbon adsorption is unparalleled.



Contaminants and vapors sorbed to GAC.

For many applications, Granulated Activated Carbon has proven to be the least expensive treatment option and can remove a wide variety of organic compounds from wastewater – including PFAS, TNORM and PCPs.

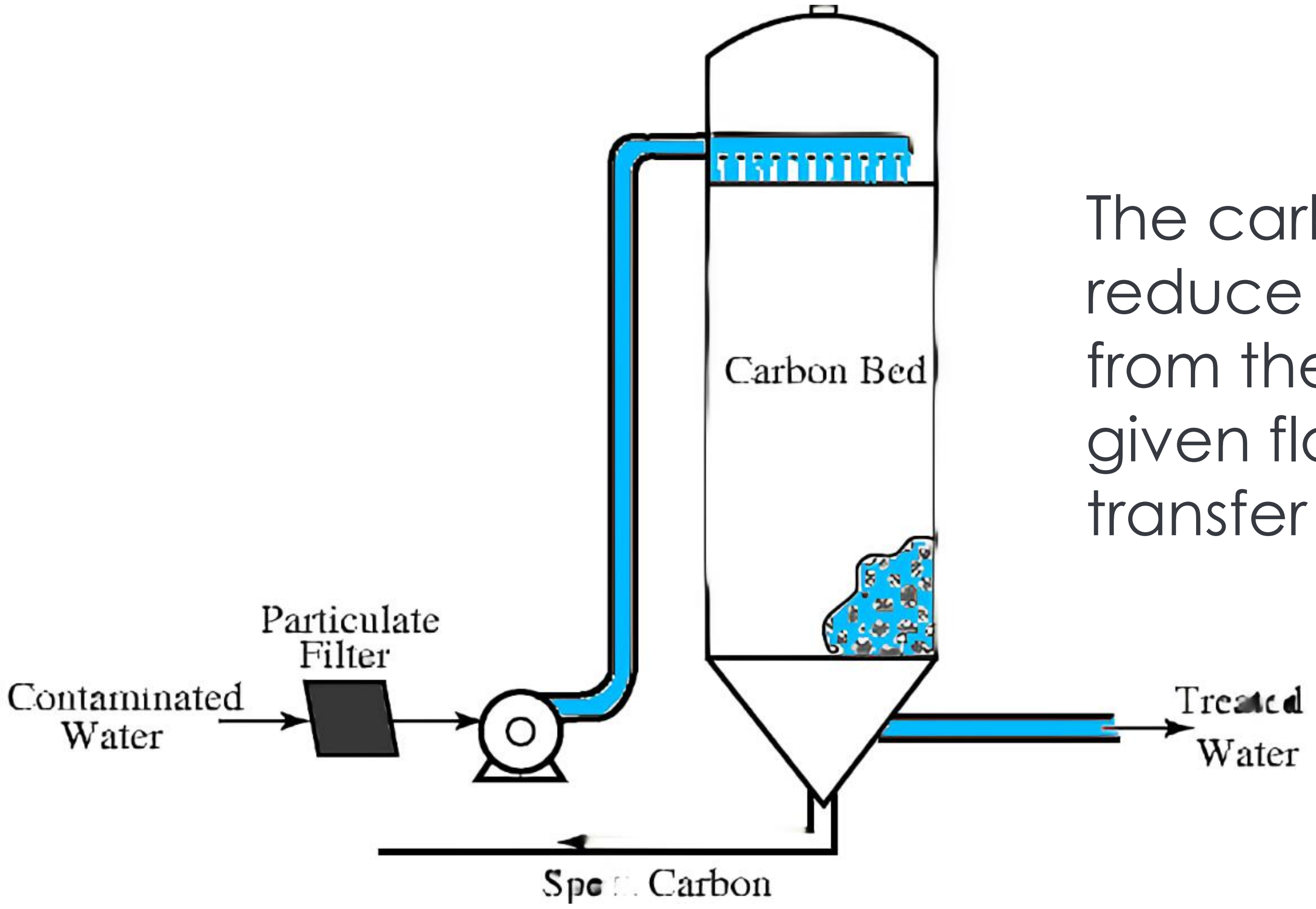


One of its most desirable attributes is that GAC can remove contaminants to below detection limits. This is especially important in potable water treatment and direct potable reuse.

Many bottled water producers use granular activated carbon to remove taste, odor, and contaminants from their product.

Adsorption is the process where an organic molecule comes in contact with activated carbon and is retained by physical or chemical forces.

As a polluted water stream passes through a confined bed of activated carbon, a mass transfer zone forms.



The carbon bed depth that is required to reduce the contaminant concentration from the start to end concentration at a given flow rate is known as the “mass transfer zone.”

Several carbon beds are often operated in series to take comprehensive advantage of the adsorption difference between breakthrough and saturation.

The mass transfer zone may then move through the first bed completely before being removed from service.

The effluent quality is maintained by the following beds in the series.

Prior to retrofitting an existing multimedia filter with GAC, or designing a new GAC filter, several practical considerations are necessary, including hydraulic requirements, filter on-stream time, and backwash water availability.

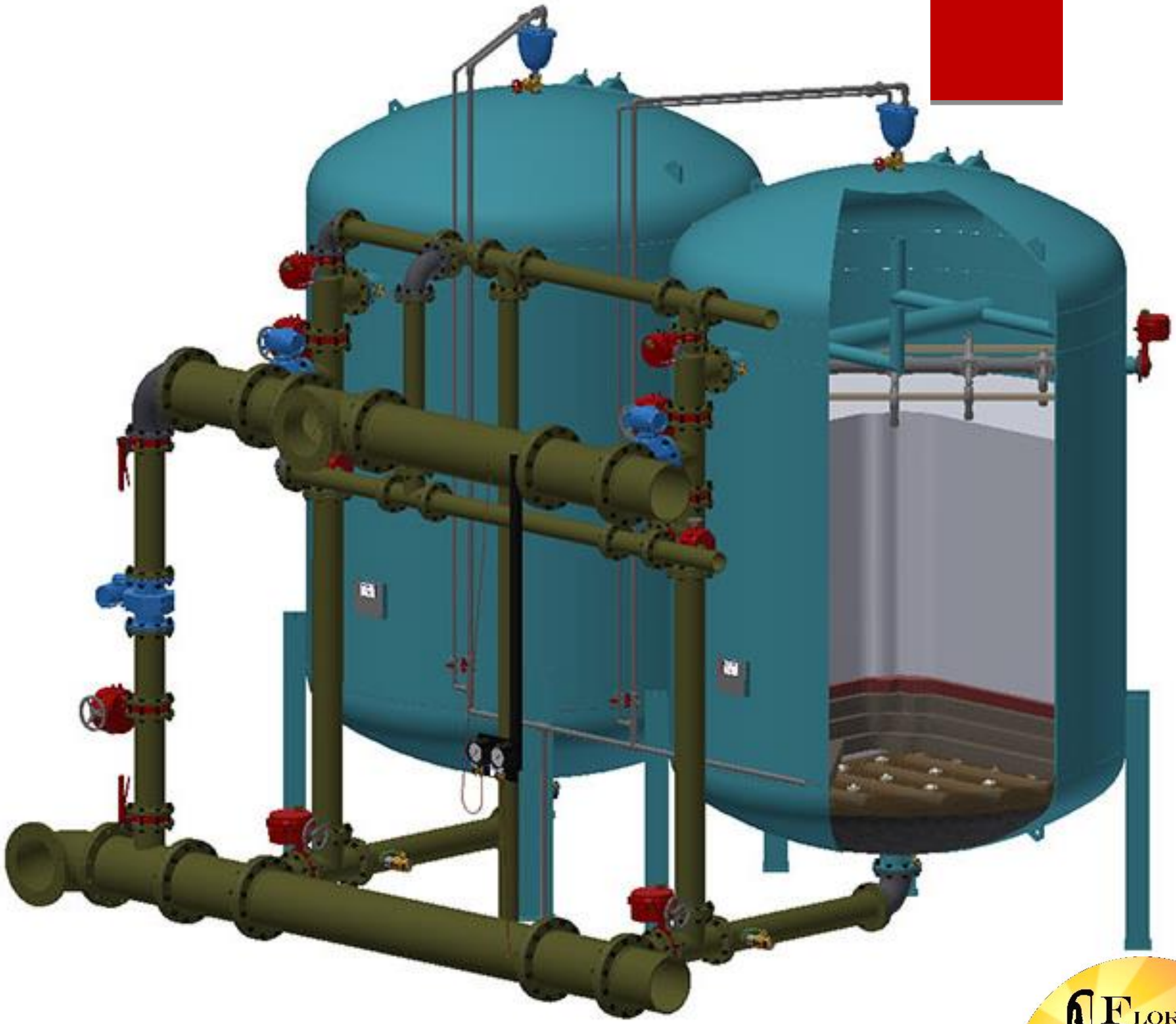
The properties of the GAC, such as adsorption performance, abrasion resistance and density must be considered as well. Additionally, the effective cost of converting the filter to GAC must be evaluated.

Polling Question

Ion-Exchange Resin

Ion-Exchange Resin Pros	Cons
▪ Effective for anionic and long-chain PFAS removal to ng/L level ▪ Higher adsorption capacity and significantly faster reaction kinetics compared to GAC ▪ Relatively inexpensive and simple maintenance ▪ Better PFAS removal efficiency ▪ Can be specialized to remove specific PFAS	▪ Not effective for wastewater containing high levels of inorganic ions (i.e. TDS) and/or natural organic matter (NOM) ▪ Less affinity for short-chain PFAS ▪ Incineration or regeneration of ion exchange resin required ▪ Must be regularly cleaned or replaced with new IX resin

Example of pressure filters for Ion Exchange



Ion Exchange Facts:

- Exchange of ions between a solid substance (called a resin) and an aqueous solution.
- The technology is engineered to target families of contaminants, like PFAS.
- Resins in ion exchange are single use in PFAS treatment, incinerated when they are saturated, and replaced with new ones.
- Because resins are replaced, the technology does not generate a contaminant waste stream that needs to be treated because the resin in ion exchange is destroyed and does not need to be regenerated.

Ion Exchange Facts:

- ❖ For ion exchange, the tiny beads that make up the resin are hydrocarbons. The positively charged anion exchange resins (AER) are effective for removing negatively charged contaminants, like PFAS.

- ❖ Ion exchange is effective at removing both long and short chain PFAs but may be more economically paired with GAC. However, it typically has a smaller EBCT and longer bed life than GAC.

- ❖ Ion exchange can also treat nearly all the PFAS within ideal circumstances of flow rate, bed depth, and resin choice.

Ion Exchange Resin (IX)

- Removes PFAS via sorption
- Must be regularly cleaned or replaced with new IX resin
- 77-97% PFOA removal, 90-99% PFOS removal, about 94-99% removal of other PFAS
  - Can be specialized for specific PFAS removal
  - Relatively inexpensive and simple to maintain

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Nanofiltration or Reverse Osmosis

Nanofiltration or Reverse Osmosis Pros	Cons
▪ Effective for both short-chain and long-chain PFAS ▪ Capable of handling co-contaminants and treating all types of PFAS-contaminated water ▪ High loading flow rate ▪ Can be partnered with a disposal well (common in North America) to permanently dispose of the PFAS brine ▪ Best PFAS removal efficiency	▪ Possible membrane fouling by scaling inorganic compounds ▪ Concentrated brine management, which can be solved through high recovery performance to minimize brine produced and disposed (concentrate the PFAS to the maximum extent in ultra-high recovery RO while avoiding scaling of RO system) ▪ Must be regularly cleaned or disposed of and replaced ▪ Influent water may require pre-treatment ▪ Expensive to setup, maintain and operate

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Reverse osmosis membrane filtration system for PFAS treatment

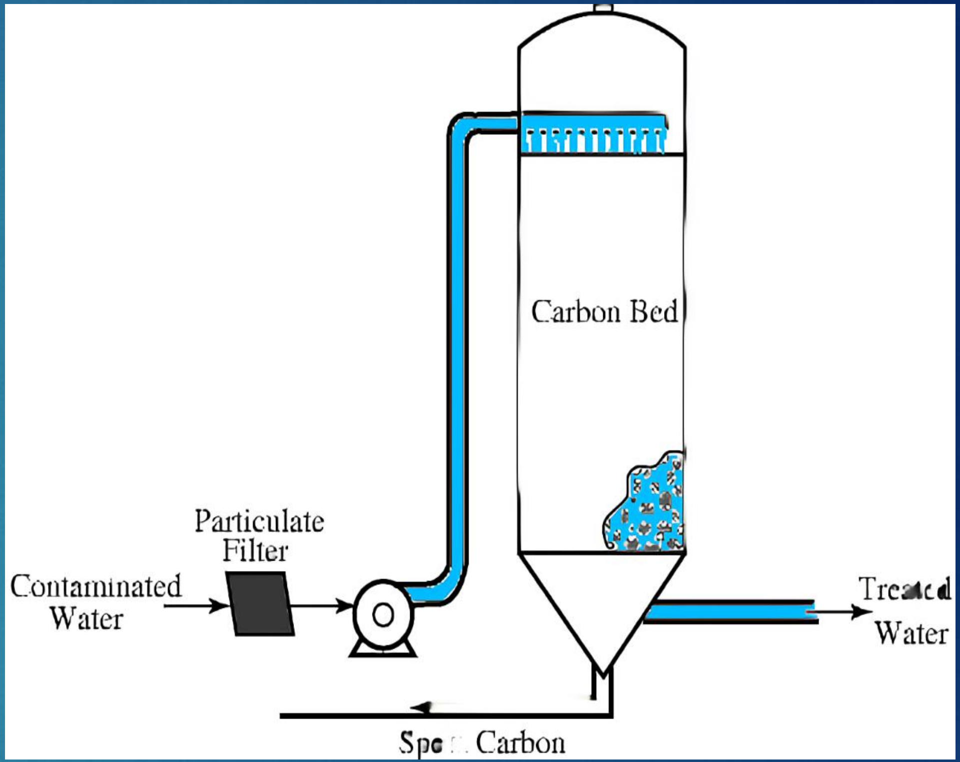
Reverse osmosis membrane filtration facts:

- In NF/RO treatment, PFAS is rejected by a semi-permeable membrane at high pressure. This produces wastewater that is concentrated with dissolved solids.

- While a high percentage of the feed water passes through the membrane as clean water, finding a way to dispose of the concentrated reject stream is a consideration with reverse osmosis.

- Reverse osmosis is typically more than 90 percent effective at removing a wide range of PFAS, including shorter chain PFAS.
- While RO is very effective, this technology may require consideration of final water quality, including remineralization steps or pH adjustment.
- Compared to alternate technologies, RO is well suited for water sources with particularly high PFAS concentrations, as it does not require frequent replacement of adsorbents.

Reverse Osmosis (RO) and Nanofiltration (NF)



- Removes PFAS via membrane filtration
- Must be regularly flushed and cleaned or disposed of and replaced
- At least 99% removal for most PFAS
- Influent water may require pre-treatment
- Expensive to setup, maintain and operate

Advanced Oxidation

❖Typically uses either Ozone or Catalyzed Hydrogen Peroxide

Advanced Oxidation Pros	Cons
▪ Breaks down PFAS into smaller or precursor compounds *Additional mechanistic studies are needed to develop chemical oxidation as a feasible PFAS remediation approach and to further assess factors that may promote or limit this technology.*	▪ Does NOT destroy or remove PFAS from water

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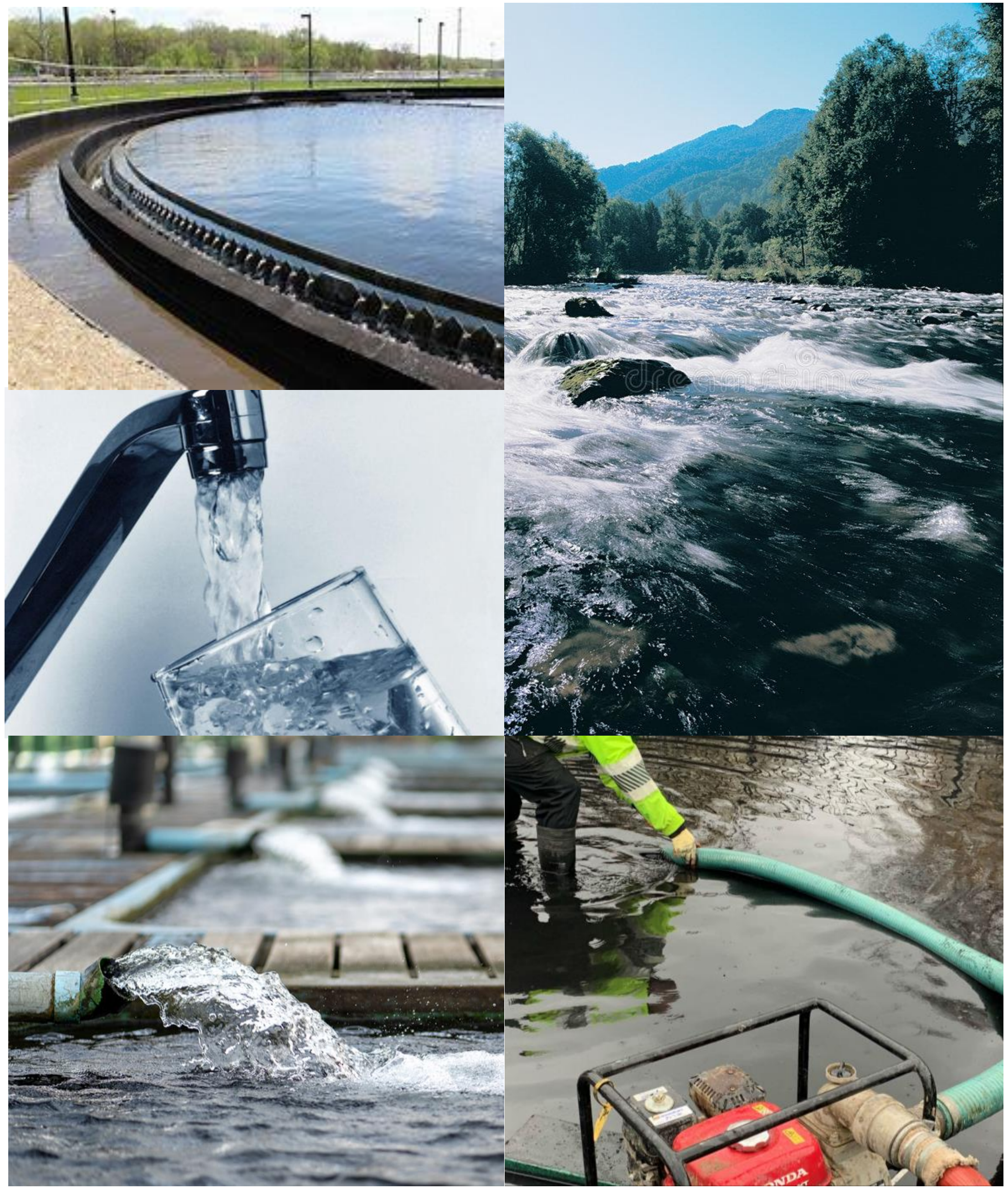
Electrocoagulation Systems for PFAS Destruction

A brand new patented and commercialized electrocoagulation process has recently been developed that not only separates the PFAS from the water, but also destroys the PFAS in the coagulated solids in less than three minutes.

NEW!

The Powell Water Electrocoagulation Process has been found effective on drinking water, clean river water, publicly owned treatment works, sewage discharge water, firefighting wastewater and on mixed landfill leachate water.

Powell Water



Powell electrocoagulation reduced PFOA and PFOS below proposed discharge limits for water and coagulated solids with the use of iron blades and hydrogen peroxide. By destroying the fluoride carbon bond, the environment is safe from PFOA and PFOS contamination.

[redacted]

[redacted]

Costs for electrocoagulation treatment meeting MCL-TCLP criteria are less than comparable treatments which only capture PFAS for final expensive destruction through incineration, encapsulation, of deep well injection.

The Powell electrocoagulation system can be permanently installed, or skid mounted trailers for treating water on a short-term basis.

FLORIDA RURAL WATER ASSOCIATION

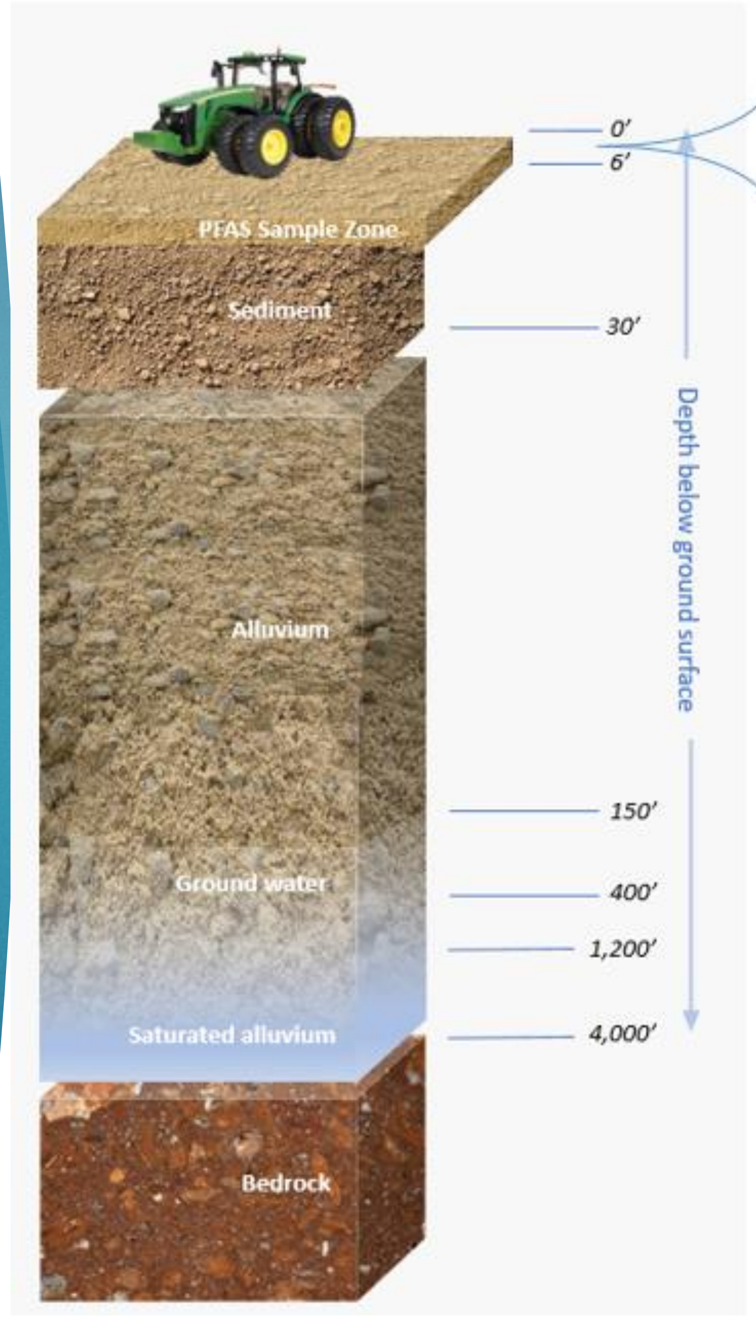
Biosolids Handling

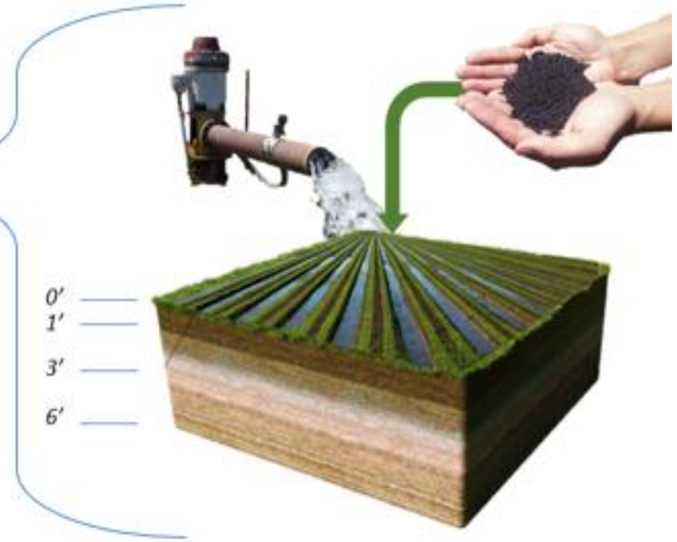
PFAS have been found in wastewater sewage sludge and much of this sludge is processed into biosolids and applied on agricultural lands.

Half of the domestic sludge produced by wastewater treatment in the United States is applied to agriculture as biosolids, allowing PFAS to enter the food chain.

In general, land application is mutually beneficial – the WWTP has a cost-effective method of disposing of biosolids.

However, land application of municipal biosolids can be a potential source of PFAS contamination in waterways through runoff from these fields.





Polling Question

Remediation Overview

Remediation Method	Pros	Cons
Pump and Treat	• Removes PFAS from environment • Effective and Reliable	• Setup and maintenance of system can be expensive
Excavation and Disposal	• Removes PFAS from location	• Labor and fuel-intensive • Only displaces PFAS • PFAS could leak from landfill
Incineration	• Removes PFAS from environment • Potentially destroys PFAS	• Not approved in all states • Very fuel-intensive • Only currently in research stage
Stabilization	• Effective • Simple • Relatively Inexpensive	• Doesn't remove PFAS from environment

Emerging Contaminants In Summary

- Physical separation technologies (Granulated Activated Carbon, Ion Exchange Resin, Nanofiltration or Reverse Osmosis) _do not_ destroy Emerging Contaminants but only _remove_ them from contaminated water onto adsorbents or into a concentrated brine.

- The disposal of Emerging Contaminated absorbents or PFAS-concentrated brine may pose secondary pollution risks.

- Technologies for permanently degrading PFAS are based on high-energy incineration or advanced oxidations including electrochemical oxidation, microwave thermal treatment, photolytic degradation, pyrolysis, and sonochemistry.

- These extreme PFAS degradation pathways are very costly, especially when the volume and the flowrate of PFAS wastewater are large.

- It is thus ideal to use other relatively cost-effective technologies to first reduce PFAS wastewater volume and concentrate PFAS into its highest allowable concentration together with co-contaminate removals.

- The highly concentrated PFAS wastewater can then be transported to either a disposal well for permanent disposal deep underground, or a PFAS-specialized degradation site for final destruction.

Florida Rural Water Association

Research has already shown that Emerging Contaminants can leach out of land-applied biosolids and percolate into underlying aquifers.

In order to break the cycle, both Wastewater *and* Drinking water treatment plants must be equipped with PFAS removal systems.

Review of course objectives

- During this training our goals were to:
  - Understand the complexity and impacts of Emerging Contaminants
  - Be able to identify the sources of Emerging Contaminants
  - Learn how chemical development initiated Emerging Contaminants
  - Identify potential treatment options for their facilities

Related documentaries regarding PFAS and PFOA

- 2018 “Devil We Know”
- 2019 “Dark Waters”
- 2020 “No Defense”

Florida Rural Water Association

City of Altamonte Springs Florida

Direct Potable reuse pilot

Filtered effluent goes through Ozone, GAC, Ultrafiltration, GAC, H_2O_2 and then UV

Questions?

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Thanks to the folks at Colorado Rural Water