PFAs summary

There has been a great deal of publicity about PFAs and PFOAs recently related to contamination of the water supply and food supply. Because these chemicals may have relevance to our water supply and the Forest Lake fish we consume, the Foundation has asked me to research and write a paper on this topic. This first chapter is an abbreviated version of the entire article for those short on time. There will be further details in the body of the report.

PFAs are not found in nature. They were originally synthesized by 3M in the 50's. The first PFA was Scotchguard. PFAs were revolutionary, as they would not break down in the environment, and they were very resistant to heat, corrosion, and could be made to repel stains and water. The uses of these revolutionary compounds would find applications in almost all phases of our life in America. Initially 3M scientists felt and stated that there was no possibility of PFAS being absorbed by humans which was very reassuring. Unfortunately, in 1975 3M scientists found PFAs in the blood in American blood banks. They did not disclose this to the EPA until 1998, and to the US military until 2000, according to court documents. In recent studies up to 98% of Americans have some PFAs in their body.

PFAs have turned out to be extraordinarily useful. The manufacture and use of PFAs have exploded, and currently there are over 16,000 different PFAs being manufactured and released into the environment. When the EPA tests for PFAs in the environment they are only able to test for about 10% of the known PFAs. This means that the measured amount of PFAs persisting in the environment is grossly underestimated.

A PFA is basically a chain of carbon molecules that have fluorine molecules attached on the sides. Because the structure of the molecules can't be broken down in the environment, their levels have continued to rise in the water and in the food supply. There are 3 basic types of PFA, short chain, long chain, and smaller PFAs. The short chain PFAs are often used as surfactants (dissolvers) and some of them have been found to be so toxic that they are now banned by the EPA. Unfortunately, some industries then moved on to similar molecules that haven't been tested yet. The human body can eliminate these smaller PFAs fairly rapidly in the urine. The long chain PFAs accumulate in the human body and take years to be eliminated. The last type of PFA is a group of smaller molecules found in air conditioners and even as propellants in asthma inhalers. The human body absorbs PFAs mainly in 2 ways. We absorb that through the GI tract in the food and water. In addition, we can easily absorb PFAs through the lungs. The lungs are the sites of significant absorption mainly in workers in industries that use or manufacture PFAS. PFAS are found in dust in many homes as well, so babies that crawl on floors etc may be particularly susceptible to inhaling these compounds.

The PFAs are known as forever chemicals because they will accumulate at gradually increasing levels in the environment, and therefore we can expect gradually increasing levels in humans. There are no known natural processes on earth that degrade or eliminate PFAS. In general, we acquire most of our PFAs from the water we drink. But they can also be present in the foods that we eat, and the packaging of our food as well.

PFAs are relevant to the residents of Forest Lake for several reasons. At least half of the ground and surface water in the US has some PFAs and the actual percentage is likely quite higher due to difficulties in measuring levels.. In addition, fish seem to be the perfect bio-accumulator of PFAs. When fish are sampled throughout the US The Great Lakes, central plains and the East Coast seem to be hotspots. Eating 1 Lake Michigan trout can be the equivalent of a person drinking contaminated water for 1 month. The Michigan DNR has put out an advisory for pregnant women to basically avoid eating rainbow smelt from Lake Michigan. There are also advisories for Lake Superior and Huron. I was surprised to see this as rainbow smelt are not high on the food chain (when I was a kid we used to net smelt during the spring spawning run and if anybody came by with an empty bucket we would "pour them a bucket") The DNR has a website related to PFAs, but as far as I can tell there hasn't been any sampling of the isolated lakes in our region. We do know that some of the municipal

water supply near Rhinelander is contaminated with PFAs. My guess is that the cause is some local industrial use or manufacturing.

In this article I will explain why it is so difficult to determine how toxic the PFAs actually are. Animals like rodents eliminate PFAs quickly as opposed to humans, so animal studies are hard to apply to humans. While a low level of PFA in the blood may not be toxic, we don't know if a higher level (which would be likely in the future) will be as benign. Also of concern is the human fetus may accumulate higher levels of PFAs, and breast milk also contains PFAs. Indeed, PFA levels in nursing babies can be higher than in their mothers. Because there are so many different PFAs (16,000 and counting), we have no idea if the toxicity of different PFAs could be additive. Because some PFAs may be hormone mimetic (activate human estrogen receptors) there could possibly be toxic effects that show up in the next generation of females (like DES babies developing an unusual vaginal cancer in the 60's). In addition, we now know of what is termed genetic imprinting where the DNA sequences of the fetus are not altered, but there are new elements attached to the DNA that alters the reading of the DNA and can be passed down through multiple generations. (The second generation of DES babies have not had any increased cancer so far but they do have more menstrual irregularities and they are being monitored closely). When you read these words you can accuse me of being an alarmist, which is true. I am not saying that these things will happen, but because these are forever chemicals we take an unknown amount of risk by continuing to produce them.

Because there are so many PFAs, and our animal models are so difficult to apply to humans we only have observational studies. It is important to remember that observation does not prove causation. When we say that some conditions are linked to PFAs this is not absolute proof of causation. Currently PFA exposure is linked to obesity, metabolic and endocrine problems like diabetes, high blood pressure and high cholesterol, poorer immune response to vaccinations, thyroid disease, female infertility, pre-eclampsia in pregnancy, low sperm counts, and testicular and kidney cancers. This means that risk from PFAS is likely, but not absolutely proven. The exact risk will take further long-term study. In the body of this paper, I will give examples of why "linked" does not mean definitely causative. However, with 16,000 different untested chemicals entering our water and food it is likely there will be some significantly toxic compounds.

The European Union is discussing banning all PFAs. This would be a monumental task as PFAs are in our cars, air conditioners, clothing, furniture, plastics, computers, cell phones, microchips, cosmetics and carpeting. In addition, the military has found the use of PFAs to be essential. It would take at least 10 years to eliminate most PFAs. Even then, there would still likely be some essential PFAs that we could not replace, because industrial production of PFAs often leads to environmental contamination, the manufacturing and recycling would have to be carefully monitored. Even if we were to agree that it would be an impossible task to determine which of 16,000 different PFAs are long term toxic risks and therefore banned production of all PFAs, we would still have to account for production from the rest of the world. As you can surmise, PFAs produced anywhere will eventually be distributed around the globe.

Given all the uncertainties involved, it will take a long time to get governments to act on PFAs. The US Congress passed the Safe Drinking Water Act in 1974, giving the EPA the power to regulate the safety of our water supply. However, in 1996 the Congress amended the Act to decrease the authority of the EPA. I would not expect quick or decisive action by the EPA. In the meantime, there are many things the individual can do to minimize their exposure which we will discuss further in the paper.

Please feel free to email me or call with any comments or questions. I am by no means an expert on PFAs, but as a former chemistry major and physician, I have a strong interest in this subject. If I don't have an answer for you (if there is one), I will try to find it. In addition, at the time of this writing, the EPA has just passed a ruling on testing for PFAs in municipal water supplies. Please see the addendum below. This is a wonderful first step and we will discuss it further in the last chapter of this report.

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ADDENDUM. As of this writing today, the EPA has just taken a significant step to addressing PFAs in our drinking water. The EPA has just restricted the levels of 6 different PFAs in our municipal drinking water. If any of the 6 levels or the aggregate of all 6 are above specified levels, the water facility will be required to treat the water to acceptable levels. Water facilities will also be required to monitor PFAs levels in the future. The facilities will have 3 years to test for PFAs and then 2 more years to implement PFAs removal.

How are PFAs used?

PFAs are all around us. These substances are in our cookware, our food containers, our clothing and cosmetics. They are in our furniture, cars, jet engines and microchips. They are in medical devices, smart phone screens, and refrigeration systems. Why are they so ubiquitous? Because they are so incredibly useful.

They are so useful because they let grease and water slide off textiles. They protect industrial equipment from corrosion and heat damage. PFAs do not deteriorate under natural conditions, so their benefits are long lasting. Unfortunately, the PFAs escape into the environment. It is estimated that tens of thousands of pounds of these chemicals escape to the environment annually in Europe alone. As mentioned previously, several PFAs are known to be toxic and are banned under international and national laws. Unfortunately, most PFAs have not yet undergone toxicology assessments.

Europe has proposed a vote on or before 2025 to ban Most. Of the PFAs with grace periods of up to 10 years, to allow manufacturers time to develop alternatives. Several permanent exemptions to the ban include for fluorinated drugs like Prozac and for materials used to calibrate scientific instruments. The idea is to shrink PFAs use to a minimum. Europeans are trying to act quickly. Their concern is that the persistence of PFAs leading to an inevitable buildup could exceed as yet unknown safe thresholds.

Over 100 companies including Apple have already pledged to phase out PFAs due to the examples of toxic PFAs. This is admirable, although it is still not clear they can find suitable materials to do the job. The search is already on for substitutes. Because of the unique properties of PFAs it is likely that multiple different substitutes will be needed.

Industrial users of PFAs are likely to have the hardest time finding alternatives. According to Nature “The simplest but most pervasive uses of PFAs is in machinery - from engines to chemical reactors -are at the interfaces between parts. Fluoropolymer greases lubricate moving surfaces, and fluoroelastomer O-rings, gaskets and seals join parts together. (Elastomers are polymers that regain their shape after being deformed.) Fluoromaterials are the only flexible ones that can resist aggressive chemical corrosion, very high temperatures, and in some applications, ultraviolet radiation”. In summary most materials made of PFAs will outlast the lifetime of the machine they are in.

The US military is heavily dependent on PFAs at this time for much of their equipment, and although the military would like to leave PFAs behind, the reliance on many PFAs will be present for quite a long time.

Fluorinated compounds have allowed the average home to have air conditioning because they are not irritants or flammable (as opposed to the older refrigerant, ammonia). The current fluorinated refrigerant in use unfortunately escapes to the atmosphere, where it breaks down to a PFA that is even harder to remove from water than the usual PFAs. Some people argue the most common-sense approach to this is to crack down on leaks. It could be possible to build systems with a refrigerant in a closed loop in that if there is a leak the device doesn’t work. In other words, improving the technology to prevent leaks might be the best answer for refrigerants at this time.

PFAs are crucial to the production of computer chips, so are heavily involved in the world race for semiconductor dominance. Because of strong demand from the semiconductor industry, manufacturers are accelerating production of PFAs. In production of a chip, the silicon wafer’s surface is coated with a PFA material and then illuminated. The PFAs generate strong acids that eat away at portions of the wafer creating a pattern. Then the wafer is “dry etched” with a gas mixture containing fluorocarbons. As a last step the

microchip may be coated with a fluoropolymer. There is considerable research to find PFA alternatives particularly by the Semiconductor Research Corporation, a consortium based in North Carolina.

In some ways the easy use of PFAs is a hindrance to innovation. For example, 3M made firefighting foams with PFAs for decades, but only switched to fluorine free foam after PFAs became a high-profile pollutant in the public eye.

We are exposed to PFAs in the clothing we wear. Goretex had a breathable membrane that was waterproof. They have discontinued the PFA membrane about 2 years ago, but the entire rain jacket remains coated with an external PFA. Even though we do not absorb much PFA through our skin, bits of PFA can break off as dust and be absorbed through the lungs. And again, a common refrain is that ultimately the rainwear will be discarded and there is no way to recycle the PFA at this time.

Of most concern is PFA exposure and absorption through food and cookware. Many plastics that are used for food containers contain PFAs that can leach into the food. Because PFAs are so useful to prevent grease leakage they have been used extensively in the fast-food industry, in food wrappers, soda cups, and straws. The EPA has just announced that production of PFA containing wrappers for fast foods will be discontinued. In addition to fast food wrappers, many other food take-out materials such as pizza boxes and fiber bowls contain PFAs.

One of the most famous fluoropolymers is Teflon (PTFE}. Teflon is marketed as a non-stick coating for cookware. It is unlikely that you will absorb the PTFE from your food as Teflon is a long chain and fairly stable, However, if the pan is subjected to excess heat the PTFE can be absorbed through the fumes generated. Of note is that overheated Teflon creates fumes will kill small birds according to Consumer Reports. Although Teflon should be relatively safe if not scratched or overheated, Teflon is produced using other more toxic PFAs. In addition, Consumer Reports recently tested a Teflon coated pan marketed as “PFOA free” (one of the more toxic PFAs) and indeed found some PFOA present in the pan coating. They tested for 96 different PFAs (more than usually tested for) and found an additional 16 PFAs present. Ultimately it appears that although other PFAs are not added to the PTFE in the pan making process, contaminants are generated by the manufacturing and curing process and are thus present in the pan coating.

In summary PFAs are ubiquitous in our lives. It is appearing that not all PFAs can be replaced at this time. The European model is to ban the PFAs that can be replaced, with a suitable grace period. In addition, Europe will place further emphasis on assuring that the irreplaceable PFAs will be recycled in a way to avoid environmental release.

How do we test for PFAs?

With 16,000 PFAs already produced and likely many others in the future it is reasonable to ask how we can test for them. We will never have a specific test for each PFA. The largest number of specific PFAs tests that I have seen have been the 96 individual PFAs that Consumer Reports used in their Teflon testing.

Some states have preliminarily determined toxic thresholds for up to 4 different PFAs in water supplies. What about the other 15,996? Luckily there is a test for TOTAL PFA levels. Because fluorinated carbons don't occur in nature, an aggregate test for fluorinated compounds will give a fairly accurate number for the level of PFA contamination. However, it won't give you any idea of how many toxic PFAs are present or their concentration.

This total PFA testing has been done in 1 paper I have seen and the result shows that our specific testing for PFAs in the environment only picks up 10% of the total PFAs that are present. In other words, we know a moderate amount about the 10% that we can test for, but the devil may be in the other 90%.

When we evaluate individuals for PFA exposure, blood levels are of some help for the long chain fluorocarbons that can persist in the body for years. However, the short chain fluorocarbons such as the toxic fluorosurfactants are problematic because they are eliminated quickly. And levels could be quite misleading.

In summary it will be difficult to regulate PFAs using chemical tests given the number of PFAs, as well as the difficulty in determining safe thresholds of exposure. This is the reason many scientists have called for regulating all fluorocarbons as a class. In other words, eliminating the PFAs that are definitively toxic, eliminating the PFAs for which substitutes are available, and allowing the PFAs that are indispensable, but with close monitoring for environmental leaks.

How do we absorb and eliminate PFAs from the body?

Most absorption of PFAs by humans occurs through the gastrointestinal tract. Currently, the major route of exposure in most Americans is through the water supply. As previously mentioned, a significant amount of the US fresh water supply contains PFAs in varying concentrations. Because pregnant women and babies consume proportionately more water, they are likely the most vulnerable to the effects of PFAs. Because many industries that make or use PFAs are near rivers, the Great Lakes, or the oceans, these are often hotspots for high PFA levels in the water.
Additionally, any industry such as paper mills that deal with fluorinated products can produce waste with high levels of PFAs. When this waste is spread on fields or put into a landfill it will almost inevitably make its way into the groundwater and enter private wells or municipal water supplies. No current water treatment plant in the US is capable of removing significant PFAs from the water supply, so the highest water exposures occur wherever the water supply has PFAs., municipal or private.

While most exposure to PFAs comes from the water supply, eating fish has been demonstrated to be a large source of PFAs in some areas. It turns out that fish are great concentrators of PFAs. Some fish from the Great Lakes contain very, very high levels of PFAs. New data shows that some people who consume freshwater fish regularly from Lake Superior, Michigan, or Huron could have “alarming” levels of PFAs in their bodies. The fish contamination was so significant that the researchers stated that eating 1 contaminated lake trout form Lake Superior or 1 contaminated coho salmon from Lake Michigan could be the equivalent of drinking PFA contaminated water for 1 month. One Lake Superior lake trout had 21,000 parts per trillion of PFOS (one type of measurable PFAs) One Lake Michigan salmon had 19,000 parts per trillion of PFOS. Recent EPA recommendations are that consumable water should have no more than .02 parts per trillion PFOS. Currently the Wisconsin DNR has fish advisories for eating fish from some of the Madison lakes and streams because of PFAs. The Michigan DNR has now issued fish warnings on rainbow smelt and advised a limit of only 1 meal per month for Lakes Michigan or Superior. For me, it is clear that I would not eat ANY Great Lakes fish given the above data if I were a pregnant woman.

An additional route of exposure is through the lungs. This is usually seen in workers who are exposed to PFA fumes, but exposure also occurs through breathing dust with PFAs laden particles. Many articles of clothing have some amount of PFA in or on the materials, and as the garments age, tiny fragments can become airborne as dust and again increase exposure to the lungs. Because babies often play on the floor, they are likely exposed to more dust-like fragments of carpet and clothing, increasing their exposure to PFAs.

As far as I can determine, there are no known PFAs that can be significantly absorbed through the skin.

Many plastics may contain PFAs, or combine with PFAs in the environment. This becomes problematic as we know that microplastics are absorbed easily through the GI tract. These microplastics are currently everywhere in our environment. We now find microplastics in human heart tissue, brains, and even in the placentas of pregnant women. These microplastics may allow PFAs to enter human tissues. You will likely hear more about. microplastics in the future. We are just now recognizing how pervasive they are in the human body, and studies are now hinting that the microplastics may have their own separate detrimental effects on human health.

Human bodies eliminate PFAs mainly through the urine, although there is a little elimination through the GI tract. Because we cannot degrade PFAs, the eliminated PFAs have not been metabolized, and thus are unchanged. These PFAs then go back into our water. The short chain PFAs tend to be eliminated quickly through the urine. However, as previously mentioned, the long chain PFAs can remain in the body unchanged for years.

How do we determine if a PFA is toxic?

If we are trying to determine if Vitamin C cures the common cold we divide patients with a cold into 2 similar groups. We then give 1 group vitamin C and give the second group a placebo. We then determine how many in each group develops a cold. These studies are usually "blinded" so that the people distributing the pills and those following up on the patients do not who know receives the vitamin C vs placebo. This prevents even subconscious bias from affecting the study. These are the most accurate studies. As you are well aware, we cannot do the same thing when evaluating a potential toxin, as nobody would willingly ingest something that was potentially toxic. Instead, we have to use a technique that is much less accurate, and much more difficult. We would look a large number of patients who were exposed to a suspected toxin and see if they developed any illnesses. If any illness occur at a greater frequency in these data sets we say the illness may be "linked" to the potential toxin.

Thus, it is very difficult to determine if environmental exposures lead to toxicity. We often read something like "substance X has been linked to pancreatic cancer". However, this is not direct evidence that X causes pancreatic cancer. For example, if we were to take 100,000 people exposed to substance X and looked to see if any of them were subsequently diagnosed with any of 40 different types of cancer we would likely find that the people exposed to X would have a significantly higher than predicted amount of 2 different types of cancer. We would say then that X was "linked" to these 2 types of cancer. BUT this does not prove that X causes these 2 types of cancer. For example, we might find that people exposed to substance X are in a profession where more people are smokers, or drink more alcohol. Both smoking and alcohol increase the risk of many cancers and could actually be the causes of the cancer rather than substance X. In addition, when we examine data of this nature we need to filter out positive findings that are not significant, but are just random. Imagine flipping a coin 100 times. If it came up heads 51 times we would not say that the odds of flipping a coin and getting heads was 51%, but instead would recognize that data like this will always have some random variation. We often use what we call a "p"value to determine if a finding like a coin landing heads more often is just random variation or is actually a significant finding. When we are trying to find if a result is significant rather than just chance we often use a "p" value of .05. This means that there is a 95% chance that the finding is significant and a 5 % chance that it is just a statistical aberration. If we were evaluating the results of the substance X and 40 different types of cancer, we would predict that 2 of the cancers would be linked, but these would just be the expected statistical variations of no significance.

In addition, if we are not careful in how we evaluate statistics in our studies, we can get erroneous results. For example, one researcher "proved" in a demonstration exercise that people who wore red shirts was "linked" with cancer when they just used raw data like we are describing.

So how do we determine if something in the environment is toxic or cancer causing? We first look at big amounts of data searching for "linkage". If we find something that is linked to cancer, then we look at different sets of data to see if the same linkage occurs. Then we look at the amount of exposure. For example, if substance X causes cancer, the people the most exposed should have the highest frequency of that cancer. If we find the same linkage, then we ask if there is some other cancer cause in the group exposed to the linked chemical. For example, are the people exposed to the chemical X more likely to be smokers than the people not exposed to X? You can see how this process is cumbersome and often inaccurate.

If we are trying to determine one thing such as smoking causes cancer, the statistics are manageable. However, with PFAs we are dealing with 16,000 chemicals released into the environment. We don't have tests for the majority of these chemicals. In addition, we don't know if combinations of PFAs are more toxic than individual chemicals. (Keep in mind that there are many millions of possible combinations of PFAs.) We don't know if any of these PFAs are non-toxic at low levels but toxic at higher levels. And we don't know if this toxicity will

show up decades later (for example cancer), or if that toxicity will be passed on from mother to daughter to granddaughter. We do know that PFA levels in the environment will continue to rise, so if a PFA may be relatively safe now, it might not be safe with higher environmental levels in the future.

Of course, we also can turn to animal studies that can be helpful. We usually use rats or mice to check for toxicity. Unfortunately, rodents don't handle PFAs like we do. Rodents eliminate PFAs quickly, rather than humans who can retain the long chain PFAs for years, so the toxicities are likely to be different. Because rodents eliminate PFAs differently than humans even equivalent dosing decisions are just best guesses. As far as I can determine there are animal toxicity studies reported for only 11 PFAs. The toxicities reported include liver disease, metabolic disorders including high lipids and pre-diabetes, reduced fertility, low pup birth weights, thyroid and endocrine disorders, immune deficiency, obesity, and cancer induction. Rodents exposed to PFAs have loser sperm counts. When pregnant rodents are exposed to PFAs, their male offspring have lower sperm counts, Again, we have to keep in mind that rodents are not humans.

Current epidemiological studies highly suggest but do not prove that PFAs exposures are related to the following illnesses in humans. Liver damage, elevated cholesterol and other lipids, decreased fertility, pregnancy induced hypertension (pre-eclampsia), slight decrease in birth weight, decreased antibody response to vaccines, thyroid disease, testicular and kidney cancer. Of Considerable concern is newer data following women who were planning to get pregnant. Blood levels of several different PFAs were obtained at the start of the study.
The women who had elevated levels of PFA took longer to get pregnant. In addition, if they had more than one type of PFA elevated it took even longer to get pregnant.

In summary the quality of the information we have to use is not great, but it is the best we have. There is no certainty about any specific PFA at this time based on what we know. Given the number of PFAs currently produced and the animal data we have, it is likely some PFAs are quite toxic, and others are quite benign. Scientists will continue to do epidemiological studies and further testing and measuring, but I fear that more clarity will be elusive. In the meantime, PFA levels will continue to rise.

I ask myself who is there to protect us from the tsunami of risk that PFAs might pose? Scientists and the EPA are working to protect us. Unfortunately, the power of the EPA has been drastically cut in the past by Congress. Initially the Clean Waters ACT was passed in 1974 and Congress gave the EPA significant power to regulate the safety of our drinking water. In 1996 Congress weakened the powers of the EPA significantly. The EPA is still reeling from the 1200 scientists and policy experts who left from 1996 to 2000. In addition, the EPA under the current administration now has been given much more work to do regarding greenhouse gases. The EPA itself feels that it is underfunded for enforcing environmental regulations and evaluating chemicals for toxicity, but I have no way to independently evaluate that. Depending on what directions future congresses want to take the EPA, I would not expect quick or decisive action. Likewise, based on history such as the Love Canal, I think politicians themselves are unlikely to adequately protect us. In that instance, it took the city of Niagara 2 years to release the reports they commissioned and warn the local citizens of the highly toxic chemicals buried beneath their houses. You may not remember the Love Canal, but there was an epidemic of deformed babies and other ailments in the area around the Love Canal. Certain environmental groups such as Consumer Reports and EWG have been shining the spotlight on PFAs for the last 5 years. Their work to clarify the potential for disaster from PFAs has been remarkable. For now though, the onus rests on us to protect ourselves.

The last chapter in my paper covers what we can do to minimize our exposure to PFAs.

How do we protect ourselves.

In view of the fact that PFAs never disappear we should try to limit our personal use of products that contain PFAs. The value of this approach is that not only will it benefit ourselves, but it will benefit all fellow Americans, and eventually the rest of the world. Additionally, we should try to limit the absorption of PFAs into our own bodies.

Eliminating personal use of all PFAs is impossible at this time, but we can limit our use. In my estimation, avoiding plastics as much as possible would be a good step. Some plastics contain PFAs and often it is impossible to determine which plastics. If possible avoid products that have protective coatings on them unless you can determine that they are PFAs free. Be careful when shopping as we use the term PFAs to encompass all polyfluorinated compounds in this article. But a label on a product is fairly likely to strictly refer to PFA, not PFOS, PFOA, etc., etc.. so it could easily contain PFAs.

One could argue that the use of plastics is not terribly harmful because they are recycled, but in reality most plastics don't get recycled, and they get put in landfills where the plastics can eventually leach into the groundwater. Scientists have a long way to go to be able to eventually recycle plastics economically and safely.

To protect ourselves from PFAs, the main focus should be on what we consume. There are 2 ways you can be sure to have a safe water supply to drink. First, you can have your water tested for PFAs. There are several companies who will do the testing for 100-200 dollars. Unfortunately, they don't test for all PFAs, but the testing can at least offer some level of assurance. The second way to cut the PFAs in your water is to install a filter on the water you drink. According to a Nature review from 2023, there are 3 types of filter that remove PFAs. Reverse osmosis is effective at removing short and long chain PFAs. Ion exchange and granular carbon are both effective against long chain PFAs. I would not install a system unless it is certified to remove PFAs. The certification should be from a national organization. These certifications certify that the filter will remove significant PFAs, and that the filters remain effective for a reasonable filter life. There are under the sink systems and above the sink systems that can cost from 150 dollars to several thousand dollars. There is also a pitcher than can be filled with water and refrigerated. The pitcher filters the water and it can be dispensed as needed. The water pitcher would be for people that don't need to consume large volumes of water at one time. In general, the filters for these systems need to be replaced every 6-12 months. There is a very good discussion of water filters for PFAs in Consumer Reports Magazine for anybody interested.

In general, I would avoid most fast food at this time, although the major fast-food chains are eliminating the PFAs coated wrappings and bags they put their food in. Straws are another source of PFAs. Unfortunately, the paper straws that avoid plastic use are coated with PFAs so they don't leak. The only straws that don't contain PFAs are metal. Because many plastics contain PFAs, try to avoid buying food that is wrapped in plastic. Likewise for plastic containers of food. According to Consumer Reports, plastic ketchup and olive oil bottles are likely to leach PFAs into their contents. Avoid products that coat your furniture to protect it. Although I love Goretex for running in the rain, I will not be buying any more Goretex in the future. I would avoid bottled water as some bottled waters have been found to have PFAs. Most cans that contain food or soda have a plastic lining. I know of no data on PFAs in that coating.

I am not sure what to say about eating the fish from Forest Lake. The DNR has not changed their previous fish advisories for Wisconsin inland waters that were primarily for mercury, and I think these are reasonable. These advisories are as follows.

Women of childbearing years, nursing mothers and all children under 15 may eat:
1 meal per week of bluegill, crappies, yellow perch, sunfish, bullhead, and inland trout
1 meal per month of walleye, pike, bass, and catfish

Do not eat musky

Women beyond their childbearing years and men may eat:
Unrestricted bluegills, etc..
1 meal per week walleye, pike, catfish, and other species
1 meal per month musky

So far, farmed fish has been found to have minimal PFAS contamination, so they may be safer than Great Lakes fish. In the past I have preferred wild-caught fish for their increased omega-3 levels, but now many farmed fish are fed omega-3 supplements. I no longer avoid farmed fish for this reason.

We recently talked about microplastics and the how easily they were absorbed through the GI tract. As mentioned these may contain or degenerate into PFAs. A recent study took 2 bowls with liquid in them and refrigerated them for about 6 months. They then microwaved each bowl for just 3 minutes. Before microwaving, the bowls contained about 580,000 particles of nano plastics per square centimeter, and 21 million nano particles per square centimeters. (Nanometers are considerably smaller than micrometers.) After microwaving there were 4 million micro particles and 4 billion nanoparticles per square centimeter. Thus, 3 minutes increased the nanoparticles by a factor of 7 and the nanoparticles by a factor of 50. While we are very suspicious that micro and nano plastics are harmful to human health, the easy absorption of these particles should make us very cautious about microwaving any food or drink (particularly including baby bottles). I personally now avoid microwaving any food or drink in plastic if possible based on this data.

For cookware Teflon may pose some PFA ‘s risk, but ceramic non-stick coatings have been adequately tested and are free of PFAs. Ideally we should use glass cups rather than plastic, although obviously it can be unrealistic with little children. Of note is that silicone and melamine are PFA free. These would be excellent choices for drinking cups for children.

Lastly how about the fish in Forest Lake? I wish I knew. Based on what I have read I have no reason to think that they have high levels of PFAs. Until adequate testing has been done there is no way of knowing. Current fish advisories as above seem quite reasonable to me.

PFAs were a very frustrating topic for me to research as it was hard to collate all the information into one report. In addition, there are a lot of unknowns. Several things however are crystal clear to me

The world is now a different place than 1951 when I was born. We are now able to synthesize so many chemicals that people could not imagine when we were children. We have seen how we can poison ourselves with lead paint, DES, and PCB’s. With the next generation of synthesized chemicals potential benefits and potential risks are higher than ever. I believe that we need to be more proactive than in the past. We need to adapt to the realities of what we can synthesize. We should no longer play “whack a mole” with new chemicals. Currently when a chemical is found to be toxic, replacement with a nearly identical chemical with no toxicity testing should never be allowed. I leave it to you, the reader with this question. Will we adapt to the new chemical realities of 2024? It’s up to you.

ADDENDUM

The EPA’s recent decision to begin monitoring municipal water supplies for 6 PFA’s and to mandate treatment for elevated levels is an excellent first step to protecting us.

The good news is that an estimated 100 million will have a safer water supply. Another great benefit is that pesticides and pharmaceuticals will also be removed from the treated water. There apparently will also be grants for well owners to have their well water tested for PFA's.

The bad news is that some water supplies will be contaminated by one of the other PFA's not tested for and therefore are not treated. In addition, without further regulation, other similar PFA's will continue to be introduced into the environment without adequate testing for safety.

In summary, the EPA is making a great first step in protecting us. Hopefully we will continue making progress on protecting our people from "forever chemicals".

PFAS FOLLOWUP

I would like to follow up with a little more info on PFAS., as this is a very rapidly changing field. I have good news and bad.

First the REALLY good news. Both Tom Macak and I have had our unfiltered water supply tested using the Cyclopure company. They test for 11 different PFAS which is quite amazing. In both houses there were no detectable PFAS! We were hoping that was the case as the watershed surrounding our lake is quite small and there are no obvious PFAS sources. This might mean that filters for PFAS are not necessary on Forest Lake. Please note that this does not address other possible toxins such as lead, mercury, arsenic, and pesticides (such as insecticide spraying).

Now for the bad news. I have a filter on my tap water from a large well known filter/water softener company). During my service call this year I asked the technician about PFAS and he told me he would send that request to the appropriate person. I heard nothing. I then called and again requested info on PFAS and their filter and I never heard back. On my third try the person answering the phone had never heard of PFAS. I gave a short explanation to him as I thought this was important. I again asked for someone in the company to call me back with further info. 1 month later I still have not heard anything.This illustrates to me that you can't count on any company completely when it comes to protecting your family.

Newer evidence suggests that for most people the primary source of PFAS is the food they eat rather than the water they drink. A large study recently published looked at dietary history and PFAS levels in the blood. There were many dietary sources that correlated with higher PFAS in the blood. These included fast food (wrapping and containers possibly), butter (possibly the greaseproof wrapping paper), tea (possibly the tea bags), processed meats (possibly the processing or wrapping), and pork (possibly contaminated feed). The people with the highest PFAS were older, higher income white males with a history of regularly eating locally caught fish. A recent study of Wisconsin residents has found that most already have detectable levels of PFAS in their blood.

The most disturbing new study on PFAS is a study on male mice. We have been concerned that PFAS affected the DNA of sperm in males or ova in females. In my previous papers on PFAS we discussed DES causing changes in DNA and the effect on the next generation of humans. PFAS have now been shown to cause genetic changes in sperm as well. In the new study male mice were exposed to levels of both short chain and long chain PFAS that were similar to the levels industrial workers are exposed. (Often studies in mice use higher than normal doses. They tried to find a comparable dose to humans who had a significant exposure.) They found that the testes of the mice CONCENTRATED the PFAS. While industry claims that short chain PFAS are not retained like long chain PFAS, this was not true in the testicles. Researchers were able to detect PFAS induced changes in the DNA of the mouse sperm. When these exposed male mice produced progeny, their offspring had significant changes in their metabolism, including how they processed cholesterol. These results strongly suggest that human exposure to PFAS in fertile people may result in harmful changes in their children. This means that it is likely important that children and fertile adults minimize PFAS exposure, or risk damage to the next generation of children by exposure to PFAS.

In summary it is wonderful news that the groundwater on both sides of the lake have tested negative for 11 different types of PFAS. However, noting that there are likely over 16,000 different PFAS, and we can't test for all of them, there is no absolute certainty about our water. Personally, I will be trying to gradually modify our family's diet to minimize PFAS exposure as further info accumulates on dietary PFAS. The bottom line is that the more we learn about PFAS, the more worrisome these "forever chemicals" become for everyone. Mark Dreyer

Mark Dreyer