Slide 1 The Challenge of PFAS

Thanks you Nick, it's my pleasure to be visiting again with ACAT as well as the CHE group. I've been looking forward to pretty rapidly, giving you kind of the big picture overview of PFAS, and we'll have plenty of time for questions.

Slide 2 – Potential Conflicts of Interest

I did want to let you know that I am serving as a witness in a PFAS related case. So I do have some biases probably about the science, but I am quite concerned.

Slide 3 – Map of Alaska

I pulled a couple pictures from different websites looking at where PFAS contamination is known I Alaska. If you look at the green here, what you can see is that is often associated with where there were military installations or bases. But there are places that haven't shown up here where we know people are highly exposed, for example Saint Lawrence Island where there others are higher. There are some examples on the North Slope as well. The absence of a dot doesn't mean its not there, but they haven't been looked for adequately.

Slide 4 – photo of AFFF-filled ditch

This is what PFAS can look like. This is a picture of aviation firefighting foam – AFFF – associated with many fire training facilites facilities and airports, especially military facilities, and you can see foam on the water and that's an indication of PFAS there.

Slides 5 – photo of PFAS-contaminated soil stockpile

There are huge stockpiles of PFAS contaminated soils. Something needs to be done with it. This is something that we can talk about later. Where do we put this material?

Slide 6 – photo of warning sign for PFAS contamination

This is a warning, warning people of PFAS contaminated water in this lake and that you don't want to drink it.

Slide 7 – What are Per- and Poly-fluoroalkyl Substances (PFAS)

So what are PFAS? There are not 10's of these or hundreds or thousands, this says over 9,000 chemicals, but I just heard yesterday from EPA that they have identified closer to 10,000 individual chemicals that could be classified as PFAS.

The important thing here is that if you look at the structure, is that you have a carbon atom here with blocks of fluorine attached to them. This carbon-fluoride bond is one of the strongest bonds. It barely occurs in nature, only a couple of rare instances and they are very difficult to break. So all the PFAS and PFAS products and currently there are about 600 specific products made in the US, impurities involved in the production of these products, and then the degradants. Teflon, Scotchguard, AFFF, all these things are trademark products that contain specific kinds of PFAS.

So, why do we have PFAS - because they are very useful chemicals. They provide resistance to grease, water and oil. However, they are highly resistant and often known as 'Forever Chemicals' because we

have no way to break them down and there is no environmental way that can break them totally down. They are highly mobile, which means they move around, so that the Arctic and pristine regions are contaminated, and many of them bioaccumulate in our bodies and in the food chain.

Now, the PFOS and PFOA, those are some of what we call long chain PFAS, and these are legacy compounds, these are no longer intentionally made in the US or in Europe. However, some of them are still being made in China. But then you have the short-chained alternatives that are less well studied. And what that means, it is terrible nomenclature, it means that instead of having 8 or more carbons, it has fewer than that number of carbons. For example, GenX is produced in North Carolina, and we have major contamination problems with Genx because the US producer used to be DuPont and then it was transferred to Chemours has a large plant in NC, and they were dumping this chemical into the river for many many years until it was discovered in about 2016. In 2018 and 2019 the state blocked that from continuing; however, the river is still contaminated. And when we start studying these short chained, and I'll show you a little data there, we start to see they do the same thing as the long chains.

Slide 8 – PFAS Groupings

So we can group these 2000 chemicals into two major groups. Some of them are present in polymers – polymers we know are very large, they tend to be very stable in the environment. And we can either have PFAS in the main chain or in the side chain. They can be peeled off from the main chain.

Then we have the non-polymers. We have things that are the per- and the poly-fluoroalkyl substances. The fluoro-telomer-based substances can be metabolized in our bodies to give you the per fluoroalkyl acids. The polymers are not going to be taken up in our bodies. About 80% of the nonpolymers in the environment and our body come from the polymers production or lifecycle and breakdown.

Slide 9 – "new" PFAS found are being found all the time!

Another point I wanted to make is that new PFAS are being found all the time.

This is a new paper that came out in 2020. A scientist from New Jersey's Dept. of Environmental Protection and EPA worked together and identified some new compounds which were not only fluorinated, you can see the PFAS part but also the chlorine part as well…..These compounds have been identified and are produced by a company called Solvay which also has a facility in Switzerland and the Netherlands. They have found these chemicals as far away, so far, as far away as New Hampshire. So you know that these chemicals are traveling atmospherically and throughout New Jersey and elsewhere so far away from the plant. There are new ones being discovered all the time.

Slide 10 – Typical Exposure Pathways

Where does exposure come from? Well, First off, let me say that PFAS does degrade. Not the actual carbon-fluorine structures, and they get through our water treatment plants. PFAS, I said are not naturally occurring products. They are produced by industry. They come from many different types of consumer goods. From AFFF firefighting foams. Unfortunately, sometimes they are dumped into the environment. They are in water and get into food and animals. They are on ropes, water proof clothing. Exposure through drinking water, from fish and marine mammals and food exposure. PFAs are transferred not only across the placenta, but through breastmilk as well.

Slide 11 – How are we exposed? [14:27]

So how are we actually exposed? Like I've said there are over 200 use categories. They've been around since the 1950's. We can talk about why....No one knew much about these since the 2000's. These are significant drinking water contaminants and ground water contaminants. Again, they're in a wide variety of products like stain resistant carpeting and fabric, used extensively in food packaging and also found in food, in pots and pans for example, they get into clothing, into packaging and AFFF and even in certain cosmetics especially waterproof lipsticks and mascara. We are exposed not only ingesting it through drinking water or food or dust, but also inhalation.

Slide 12 – We ALL Have PFAS in Our Bodies

All of us have PFAS in our bodies and this is true around the world. The CDC does its annual report card, and essentailly everyone in the US has measurable amounts of PFAS. Now PFOA and PFOS intentioanl production stopped in 2002 and DuPont stopped intentional production in 2013, so what you can see is that the level of PFOS in blood appear to be going down. To a lesser extent in PFOA. Maybe they are flattening out, like PCBs, where because there is so much in the environment that it keeps coming back into our bodies. If you look at some of the other PFAS, PFDA and PFHxS levels haven't changed much at all.

Slide 13 – PFAS in Human Breast Milk

And this is some more recent data looking at human breast milk and it looks like PFOS is coming down, at least in breast milk. This is a pretty flat line for PFOA, relatively flat for the last 5 years. But if we look at some of the short-chained, what we see is that these levels are going up in breastmilk and that reflects increasing levels in products and the environment.

Slide 14 - Deposition fluxes (ng/m2*yr) and concentrations (ng/g dry wt) of PFOA, PFDA, PFBS and PFOS in a dated sediment core from Lake Hazen

If we look at what is happening in the Arctic...This is data from Northern Canada. What you can see here is that if you look at the flux over the concentrations, PFOA is still going up and still arriving in the Arctic and in fact the concentration hasn't changed very much. PFDA, the flux is still increasing. The same for PFBS and PFOS which has since stopped being made in the US in 2002, yet it is still increasing in the air and not decreasing in the sedeiment cores.

Slide 15 - Watersheds with point sources have higher detection frequencies for PFAS

The EPA database reported in 2002 that 6 million people were drinking water that could be contaminated with detectable PFAS. I should say that these measurements were made with a very high detection level and they were really focusing on PFOS and PFOA. The importance of this slide is that if for eample the water was close to a military site or firefighting area or airport, they use AFFF till October of this year (2021), and wastewater treatment platns, the water there is more likely to be contaminated with PFOA and PFOS.

Slide 16 - Predicted increases in serum perfluorooctanoic acid (PFOA) concentrations from consumption of drinking water with various concentrations of PFOA

IN fact, both the PFOA and PFOS, that if your drinking water concentration go up, its contribution to your body's levels go up. The enforcement factor the EPA uses for drinking water for this class of chemical

PFAS contamination is coming from drinking water. The important thing here is that this is looking at the 95 percentile of the American population at a similar time point, this is looking at people who are drinking water concentrations at 100 ppt and then here you see how much higher their blood levels would be, and the blood levels are of course are _____ you can replicate the PFOS and PFOA in your water and multiple it by 100 or 200 and get your approximate concentration in your blood. If you're drinking contaminated water, that will appear in your body as well.

Slide 17 - PFAS in Fast Food Packaging

There are other sources that I mentioned, for example fast food packaging. This is interesting data where they looked at the total organoflourine in different kinds of food packaging. It looked like the things that your muffins might be in or burgers all contained PFAS. And the PFAS in many cases were PFOA, PFHxA, PFBS, and 6:2 FTS. And recently, FDA has actually made an agreement with the food packaging people not to use, for example, some of these chemicals in production and they have until 2025 to stop using it.

Slide 18 - Long-Chained PFCA's strongly associated with seafood consumption

We also know that people eat more fish or shellfish or whales have higher levels of PFAS. This is data from children in the Faroe Islands in northern Scotland and Iceland in the North Sea. What you can see is that children that eat a lot of whale meat have higher levels than children who don't eat what meat. We know that whale meat has high levels of PFAS.

What you can see is that people in Massachusetts have more PFDA the more shellfish they eat.

Slide 19 - PFAS-exposure related health concerns began

These regulations should have been done long before it did. Because in fact we know now that DuPont already had concerns in 1962 about health risks for people occupationally working on their production lines with PFAS. This is not 'nobody knew about this'. In fact, by 1978 DuPont and 3M had studied adverse effects of PFOA in monkeys, PFAS were detected in the serum of workers in the late 1970's, but this info was not released to the general public. These studies found In 1987 that PFOA causes cancer in lab studies especially testicular and pancreatis cancer. It was only in the 1990's that 3M was monitoring of PFOA in their workers. Because orignall PFOA was made by 3M and sold to DuPont, but when DuPont started making it themselves in North Carolina. 3m announced in 1998, that US blood donors contained PFAS which led to their decision to stop making PFOS. In 2012, noted suppression of immune response in children who had been exposed to PFAS. DuPont was sued in 2001 in a class action lawsuit. This is a very well known study called the C8 Study. This was settled to fund a study to study the health effects of PFOA in 65,000 – 69,000 people. Then GenX began being used as a substitute and now the findings of GenX were first reported in 2015 and 2016.

Slide 20 - Wide Range of Health Effects of PFAS

So there' sa new wide range of health effects of PFAS. These are data specifically from PFOS and PFOA. Essentially all these effects have been seen in not only in experimental animals but in people as well. So the C8 Study in Ohio and W Virgina noticed associations with testicular and kidney cancer, ulcerative colitis which is an autoimmune disease, high cholesterol, pregnancy-induced hypertension, disruption of thyroid signaling, and effects on other hormone systems, obesity and type 2 diabetes, immunotoxicity, interference with child and adult vaccine response, Our current data parallels what we've seen in rodent

data, lower birth weight, decreased fertility, decreased lactation in women may be related to mammary gland development, reduced testosterone, prostate cancer and ovarian cancer.

Slide 21 - PFAS: Multi-System Toxicant

We can say that PFAS as a class is a multi-system toxicant effecting our endocrine system, associated with cancer in several systems including our reproductive organs, effects of neural development especially memory and behavior, effects on the thyroid like diabetes, immune suppression, and effects on the liver such as elevated cholesterol.

Slide 22 - Are Replacement PFAS Less Toxic?

So the question is are the replacement PFAS less toxic? And studies coming out both from the US EPA and NIEHS have shown for example that GenX causes many of the same things as older PFOA. The NIEHS study uses mice and the EPA studies are on rats. A research study showing similar metabolic outcomes in adult mice from in utero exposure. Studies showing that GenX has similar effects to PFOA, but a number of different PFAS have been tested and duplicated and show similar effects. This biproduct (Nafion BP2) was being used as an alternative and has been shown to bioaccumulate in mice. It has been seen in human serum in North carolina. We also see the fluoro-telemer alcohol, in both of these cases we see increased inflammation and cell death in mice.

NTP looked at seven different PFAS and they showed that the C4 sulfonic acid and C6 cylic acid. I'll show you that data in a minute. NTP also showed that PFOA caused pancreatic cancer in males at the lowest dosage tested. So again the new PFAS when tested seems to be the same things as the older ones.

Slide 23 - Hepatocyte Hypertrophy

This is just some beautiful data. I had to show you a little bit of this. This is showing the hepatocyte hypertrophy. This is data coming out of the NTP 28 day studies. What you can see are these beautiful parallel dose / response curves. This is PFBS, this is PFOS, etc. It may take more of an administered dose, but in fact it does the same things.

Slide 24 - Key Research Questions

There are some key research questions that we need to address. A very important one is are we measuring 90% or 10% of the PFAS in a sample? I'm going to show you some data that is really concerning here. How do we get rid of these chemicals and make sure that they come through wastewater treatment plants? We can filter them out. The classical ones, we can get out with activated charcoal filters. But that doesn't do a good job of removing the short-chained ones. And many of the alternatives, so we have to go to reverse osmosis which is much more expensive. And then what do you do with what you removed? Do you incinerate it, do you put it in the landfill? Incineration has not been shown to be functional on an industrial scale. Or thermal oxidation can be used, but what do you generate? Sometimes you just generate other PFAS in the process.

We've got to begin to ask questions like Cousins et al, 2019, like where do we really need these chemicals and where can we replace them with safer alternatives? I specifically say safer alternatives because what I think has happened is that industry has moved to the short chain PFAS and they are equally as persistent in the environment, and when you actually test them, they do the same thing as the long chain PFAS. You want to find things that will do things like legacy PFAS and not go away.

There is a proposal that maybe we should treat PFAS as a class. There are over, as I said, 9,000 chemicals of these. Can we treat them as one class or sub-classes. There are just too many that we can't do traditional toxicity testing on them. The national academy was contacted by the consumer product safety commission asking "could they use a class approach for all fluorinated flame retardants?" and they said that certainly, a subclass approach is definitely justifiable.

Slide 25 - Pilot data suggest large increase in unidentified PFAS in drinking water: Consistent with production trends

I raise the issue of what are we measuring vs what actually is in there. This is some data from water off the coast of Massachusetts. The gray is the detectable organic fluoride. This is not for example fluorine that has been added to drinking water. This is from PFAS. This does include from pharmaceuticals, but the percent is pretty low. What you can see is that this data from 2016 – the great majority of this is we don't know what it is. And that continues for different locations. The yellow are per-fluoronated carbalcylic acids. The dark red is PFOS. The orange is PFOA. So what you can see is that there is lots of stuff that we don't know what is out there. I can tell you looking at the _____ river, and this is from 2017, only about 30% of the organi-fluorine in the water can be identified as known PFAS. And that was using upwards of, the EPA, when they did this had 49 standards.

Slide 26 - Next data slide

This is some very recent data out of Sweden, which I think is pretty concerning. This is out of a town called Wallaby which is highly contaminated by AFFF that contained PFOS. What you can see here is that adult Females, is what you can see is overly 70% of the contaminant is unknown PFAS. Branching PFOS or Linear PFOS can be identified and a little bit of PFOA and PFHxS. This study used 60 authentic standards that they could test. Most of the stuff they don't know what it is. What's interesting here is that there appears to be a male / female difference with more unknowns in females. And the amount of unknowns appears to decrease with the age of the individual. Part of this might be a funciton that these are such persistent chemicals that PFOS was more heavily used in the past then it was today. What we can see is that even in a 70-90 year old men that approximately 30% of the PFAs is unknown and you have more PFOS and PFOA. So this is a huge issue, what else is in our blood?

Slide 27 - Scientific Basis for Managing PFAS as a Chemical Class

I mentioned the growing emphasis to possibly managing PFAS as a class. The European Union just a year ago issued a Chemical Strategy of Sustainability Towards a Toxic Free Environment and exclusively called PFAS as a class and they said we need to remediate contamination on a global scale and create regulations that stress that PFAS is persistent, mobile, and hazardous.

Slide 28 - EPA's PFAS Strategic Roadmap

Just a few months ago the administrator Michael Regan announced the EPA's PFAS Strategic Roadmap. Admitting the PFAS has some unique values to deal with and to use a lifecycle approach. We have got to get upstream of the problem, in other words preventing this from happening. The polluters need to be held accountable, and we need science-based decisions, and protection of disadvantaged communities. These lower-resource communities are also those that are living next to fence lines or airfields. EPA defines the strategic road map goals, the research and remediation. They will work with ALL stakeholders, treat all the stakeholders the same, and integrate across the federal government, not just

the EPA but the FDA, DOD, CPSC, and so on. Local governments as well. EPA is proposing to divide PFAS into 24 categories. They have identified what they feel is the representative PFAS in these categories.

Slide 29 - New EPA Risk Assessments for 5 PFAS

In November 16, the EPA, they came out with new draft of risk assessments for PFOA and PFOS. OI think this is really important because in 2016 they had released what were lifetime health advisories of 2 mg / day. So PFOA and PFOS, so this is actually goes along with a drinking water level of approximately 70 parts per trillion in drinking water. What they came out with in this new draft.... by a subunit of the EPA Science Advisory Board is that they will continuing to look at this issue, and they are coming out with chronic RIB's in the neighborhood of PFOS at .79 ng/ kg / day and lower for PFOA at .15 ng/kg/day. I can tell you that if you do the work calculations, this comes out to about 2 ppt in drinking water and 1 ppt in drinking water. That's assuming a 70 kg person drinking 2 liters / day. That has not been adjusted for example for susceptible populations like lactating mothers or infants, that number would need to be lower. These new levels are much much lower then the lifetime health advisory was.

In the beginning of November, the EPA came out with ... .3 ng/kg / day which is extremely low. For PFBS is 10 times less toxic and PFBA..... This is the second one released by the EPA. The first one was released under the Trump administration and it turned out that there had been political interference in the science

Slide 30 - ATSDR's MRLs (2021)

So I wanted to compare these numbers with what I told you was the ppt for an adult. The new values are …. These are the levels based on the ATSDR's minimum risk levels that came out in May this year. Again, ATSDR's said that ingestion Again, the EPA's numbers are considerably lower. They are also lower than the Eu safety regulations that are for the sum of these 4 compounds.

Slide 31 - US Federal "Regulations" on PFAS

So, what are the US Federal regulations on PFAS – well there aren't many. I should have said that the EPA is committed to comulgating a risk assessment of PFOA nd PFOS and putting it out there by 2022 and finalizing it by 2023, bu there is currently no fed regulation of ground water or ….. superfund yet. 2022 the 172 PFAS added to Toxic Re...

Food contamination with the FDA does regulation 7 legacy PFAS. The four that I mentioned in the last slide and a few others. or will by 2025.

The Department of defense announced a total ban of PF by 2025. THey are funding a number of studies .. There are no, by 2024, they can no longer have any in food packaging on _____ property.

The FAA does not re Most of the rest of the world does not.... If you go to _____ there is AFFF there.

Slide 32 - States are moving ahead.....

California

27 states are considering policies... because of the presence of PFAs in food packaging many of the major grocery and restaurant are consider

Denmark actually banned all PFAS in food packaging over a year ago, and

Slide 33 - In Effect State Drinking Water MCL's for PFAS

So there are some state drinking water MCL's for PFAS, not waiting for the federal government to come out with them.

These are all higher than …. and we'll see what the ___ says about that

What's importatnt to know here is that Massachusets and Maine have set a regulatory limit of 20 ppt of

And Vermont regulations five of

Alaska, as far as I know, currently does not have specific regulations.

Slide 34 - Alaska Department of Environmental Conservation

Alaska relies on and adopts the US EPA hopefully they will by 2023. I can tell you that recent risk assessments will lead to a MCL of zero evaluated as a carcinogen

The Dept. Of Transportation established an action level for ground and surface water, and ____ level for long chain and short chain. They're saying that the action level of 70. That level is likely to change. As the state reviews the new risk assessment

Slide 35 - Recent court judgements against PFAS polluters are only a drop in the bucket compared to annual sales

There have been some recent court judgments against Chemours and DuPont.

Their net sales were over $6.6 Billion. If you look at 3M, they have

While these may seem like large judgements, these are very small percentages of large profits.

Slide 36 - Six urgent questions relevant to science, technology and policy that must be tackled to address the "PFAS problem"

There are six urgent questions

We really need to know the total global production....

A lot of the legacy PFAS are still being made, for eample China, and where are they being used

…. we have almost no data from the Southern Hemisphere and less developed nations

Describe

Unknown PFAs hotspots, there are lots of PFAS that has been deposite in the Arctic like dioxins, chlorine pesticides...

PFAS contaminants ….. I would love to see some research going on that ….. filter out of water, so the _____ could be reused

How do we deal with the cost, and that includes the health cost

Slide 37 - Final Slide – Thank you! Questions

I strongly recommend this YouTube video. This came out a few months ago. It is very entertaining and concerning.

Thanks a lot.