

TPWKY

This is Exactly Right.

Erin Allmann Updyke

"My love for my husband has become stronger since I fell ill with this disease. My mouth quivers so badly that I can't touch the food people bring me so I give all my presents to Mohei, he's been so helpful you know, so kind. Did I tell you before that I am his second wife? We met through a matchmaker. I came here from Amakusa. Less than three years after we got married I fell ill with this strange disease. Such bad luck. I can't even adjust my kimono. Look how I shake. No matter how often I tell my body to stop shaking, it won't obey me. I can't control my own hands and legs. Whenever he comes here my husband helps me adjust my kimono, muttering that I've become a helpless woman. Once he said I should wear underpants because my kimono kept falling front so he brought me long drawers and helped me into them. As he helped me into the pants I said to him, 'I have really become a helpless creature, my dear.'

I want to get my own body back the way it was before, I want to go back to the strong, healthy body with which I came into the world. I've never been sick, I've never had to stay in bed, I was brimming with energy, I could work harder than any man. It used to be so lovely out on the sea. I want nothing else, just to be like I was before I got this strange disease, to be able to row a boat and to land a net again. I feel so miserable now, a helpless wretch with a body like a freak. I can't even wash my underwear when I have my period. If I don't work my family won't be able to make ends meet. Minamata disease is hell. I feel like I was drifting away from this world. I have no grip, I cannot hold my husband's hand in mine, my arms shake so hard that I can't even draw my own dear son close to me.

I might even bear this if I could go on living somehow but I can't eat, I can't even bring the rice bowl to my mouth, I can't hold my chopsticks. When I walk it's not like putting one leg in front of the other on the ground but like floating on air. I am afraid. I always get that feeling that someone is trying hard to pull me out of this world, roots and all. I feel so lonely. You healthy people have no idea what it's like to lie in bed sick and forgotten by all. My husband is the only person I can still rely on, he is my only hope. I love him so much that I'd give my life for him. God, I wish I could use my hands and legs again, I wish I could work again like I used to."

TPWKY

(This Podcast Will Kill You intro theme)

Erin Welsh

This is gonna be a tough episode.

Erin Allmann Updyke

For so many reasons.

Erin Welsh

Mm-hmm. So that was excerpted from a book titled 'Paradise in the Sea of Sorrow' by Ishimure Michiko.

Erin Allmann Updyke

And that was a description of course of someone suffering from Minamata disease.

Erin Welsh

Right. Also known as methylmercury poisoning. Hi, I'm Erin Welsh.

Erin Allmann Updyke

And I'm Erin Allmann Updyke.

Erin Welsh

And this is This Podcast Will Kill You.

Erin Allmann Updyke

So today we're talking about mercury.

Erin Welsh

Mercury, yeah. It's a very big and very challenging topic for a number of reasons.

Erin Allmann Updyke

Yeah. Listeners we have been just talking amongst ourselves about how much of a challenge this episode has been for us.

Erin Welsh

Yeah.

Erin Allmann Updyke

The biology has been a real struggle trying to not only piece all of the complicated parts together but to be able to tell the story in a way that makes sense and is easy for me to explain.

Erin Welsh

And I think in both respects, both biology and history the scope is enormous.

Erin Allmann Updyke

Enormous.

Erin Welsh

And so I think figuring out what to concentrate on has been difficult but also as I did research for this it was really emotionally difficult as well, like it's a very heart-wrenching and horrifying disease, well Minamata disease specifically but just like the kinds of things that mercury can cause. Not all the time, as we will find out I'm sure Erin. I do think though it'll be a very interesting one, this is our second heavy metal.

Erin Allmann Updyke

Yeah.

Erin Welsh

Yeah.

Erin Allmann Updyke

But yeah this'll be a very different episode I think though than lead.

Erin Welsh

Yeah, yeah. For sure it will.

Erin Allmann Updyke

Yeah.

Erin Welsh

But one thing will be the same.

Erin Allmann Updyke

And that is that it's quarantini time.

Erin Welsh

It is. What are we drinking this week?

Erin Allmann Updyke

We're drinking Quicksilver.

Erin Welsh

Quicksilver. It's the other name, common name for mercury.

Erin Allmann Updyke

Do you know that I did not know that until we researched this episode?

Erin Welsh

Really?

Erin Allmann Updyke

I had no idea that that's what... Quicksilver was a skate brand to me and a surf brand.

Erin Welsh

It was a band from the 70s for me, I had my parents' old albums. (laughs)

Erin Allmann Updyke

(laughs) Oh my god. I did not.

Erin Welsh

That is hilarious.

Erin Allmann Updyke Yeah. Anyways, what's in a Quicksilver?

Erin Welsh It is vodka, cucumber, lime, and a little bit of basil simple syrup and a little splash of soda water at the end.

Erin Allmann Updyke So refreshing.

Erin Welsh And we will post the full recipe for this quarantini as well as the nonalcoholic placeborita on our website [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com). Other business?

Erin Allmann Updyke We have a website, it's [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com).

Erin Welsh Yep.

Erin Allmann Updyke And we have so many things there from merch to [bookshop.org](http://bookshop.org) to transcripts to all of the lists of our sources, we now have a Patreon, we have so much available there, check it out.

Erin Welsh Yeah. Do it. Okay should we get started on this episode?

Erin Allmann Updyke We should. Right after this break.

TPWKY (transition theme)

Erin Allmann Updyke Mercury is an element, Hg, also called hydragyrum? Maybe.

Erin Welsh Something like that.

Erin Allmann Updyke Something.

Erin Welsh There are too many 'R's in that word.

Erin Allmann Updyke Consonants.

Erin Welsh It's no wonder that it was changed to mercury to be honest.

Erin Allmann Updyke Mercury. (laughs) And like Erin said already also called quicksilver. So this is a heavy metal that is naturally found in the earth's crust however the majority of the sort of bioavailable mercury that we are exposed to as humans has been put into the mercury cycle, which we'll talk more about very much later in this episode, from anthropogenic sources.

Erin Welsh Mm-hmm.

Erin Allmann Updyke Mostly the burning of coal which releases mercury vapor as well as gold mining, some various forms of gold mining and a lot of other industrial products.

Erin Welsh Yup.

Erin Allmann Updyke

So mercury, I'm sure that everyone is at least vaguely familiar with mercury because it is so fascinating to see because it's the only metallic element that is liquid at room temperature and looks like it's something out of a sci-fi film.

Erin Welsh

Absolutely.

Erin Allmann Updyke

Totally doesn't look real. But this liquid form of mercury as we'll find out is certainly not the type of mercury that causes the most potential harm to humans or even other animals and wildlife.

Erin Welsh

Yeah.

Erin Allmann Updyke

So I wanna just disclaimer even though we kind of did already, there's a lot to cover when it comes to this nitty gritty of mercury, I hope that I do an adequate job. Let us try. So mercury comes in a number of different forms and each of these different forms has a different level of potential toxicity to humans. The three overarching categories of mercury that you can be exposed to are elemental or metallic mercury, that's quicksilver, inorganic mercury which is mercury that is bound to like a chloride or a nitrite, this is what used to be used - not to step on your history toes Erin - but as vermilion many, many moons ago. It's like a rock that is a color that was used for pigment. That's inorganic mercury.

Erin Welsh

Mm-hmm. Don't worry I'm not gonna talk about it.

Erin Allmann Updyke

Oh good. And then there is organic mercury. Organic mercury is mercury bound to carbon and hydrogen. So these all differ in terms of both exposure, like how we get exposed to them, and also bioavailability, how much they can sort of disperse throughout our body and then cause damage. So let's go over the broad strokes differences between these and then we'll talk about how similar they actually are once they make it into your body and then we'll go over the symptoms kind of organ by organ. Cool?

Erin Welsh

Sounds good.

Erin Allmann Updyke

All right. So elemental mercury aka just plain Hg, that is the liquid metal but the way that you're more likely to be exposed to it is not by that metal itself but is by mercury vapor. So elemental mercury if you ingest it, like you swallow it, it's really not absorbed really well through the GI tract. Something like 0.01% is one estimate I saw, definitely less than 1% is absorbed. Do not drink mercury though. But yeah so elemental mercury vapor, it's vaporized very quickly and easily even at room temperatures but definitely when it's heated. And when it's inhaled it's absorbed very rapidly across your respiratory membranes, like 80-100% of it is absorbed across your respiratory membranes. And from there it can very rapidly diffuse across other membranes in our body including the blood-brain barrier and the placenta. Additionally mercury vapor has a relatively long half-life in our body, about 60 days, and so it hangs around for quite some time and can kind of build up especially in organs like your brain.

Erin Welsh

Mm-hmm. Okay.

Erin Allmann Updyke

So that's elemental mercury and how we get exposed. Then there's inorganic mercury which I'm not gonna talk a ton about because it's probably the one that you're least likely to be exposed to. But these can be absorbed through the skin or the GI tract if ingested. But only about 10% of ingested inorganic mercury is actually absorbed. So again it doesn't actually absorb very easily.

Erin Welsh: And the fact that it doesn't absorb very easily just has to do with like binding? Like what exactly...

Erin Allmann Updyke: Erin, listen. I asked for you to not ask me these difficult questions!

Erin Welsh: (laughs) I'm sorry, I couldn't resist.

Erin Allmann Updyke: But yes it's essentially that our intestinal membrane doesn't allow it to easily pass. And when we get into the next one maybe that will make a little bit more sense. Let's get into it.

Erin Welsh: Okay.

Erin Allmann Updyke: Because then there is organic mercury. I'm gonna spend a little bit more time on this. Organic mercury is formed when bacteria in the ocean or the soil or our waterways take inorganic mercury like metallic mercury or inorganic mercury ions and what they do is they methylate it which means they add a carbon and some hydrogens. And when mercury is just floating around as an ion or as a metal it's not very bioavailable. It's not like attractive for plants or animals, like they can't use it when it's just in that form. But now all of a sudden it's connected to a carbon atom, now it's very bioavailable.

So this methylmercury can be used by plants, can be taken up by plants and then those plants can be eaten by little fish that will hold onto that mercury and then larger fish will eat those fish and on and on up the food chain. And this process is called bioaccumulation where that mercury stays within the system and by the time it makes its way up to predatory fish like tuna, sharks, swordfish, or other large-bodied ocean predators especially you can have very, very high levels of this methylmercury in their muscle.

Erin Welsh: Right. Which is why there are all those warnings about how much canned tuna you're supposed to eat and so on, the whole biomagnification.

Erin Allmann Updyke: Exactly.

Erin Welsh: Question.

Erin Allmann Updyke: Is it gonna be a hard one?

Erin Welsh: Maybe.

Erin Allmann Updyke: Okay.

Erin Welsh: Why/how do bacteria do this?

Erin Allmann Updyke: Great question. Bacteria are phenomenal in general at making inorganic nutrients into organic nutrients and therefore available. That's what they do with nitrogen, that's what they do with phosphorus, that's what they do with all kinds of different ions. And that's the best answer I'm gonna be able to give you.

Erin Welsh: Okay. (laughs) Okay, gotcha.

Erin Allmann Updyke

(laughs) It's like what they do, that's like their point - not their point but that's like a huge part of the contribution of bacteria and fungi who do this in the soil as well to the sort of nutrient cycling in the environment.

Erin Welsh

Right.

Erin Allmann Updyke

So that's how methylmercury exists. And then of course we eat a fish and now we're exposed to it. So methylmercury, this organic mercury is by far the largest contributor to our general exposure to mercury as humans. Not only because we're exposed to it through the consumption of things like fish, shellfish, etc but also because it is almost 100% absorbed through the GI tract in addition to potentially being absorbed through the skin or inhalation if you were to be exposed that way.

Erin Welsh

Mm-hmm.

Erin Allmann Updyke

So of the forms of mercury it's probably the most easily absorbed especially through the GI tract. And once it's absorbed it can very easily and readily distribute itself throughout the body. It can cross the blood-brain barrier and placenta and we'll talk a bit more about how it does that in just a minute. And even more concerningly than elemental mercury, the half-life of methylmercury in the body is longer. It's 70 days or sometimes longer and the way that it's excreted is different. So it's excreted in our feces, it has to be conjugated in our liver and then we have to poop it out whereas other forms of mercury like inorganic and elemental mercury we actually excrete in our urine.

Erin Welsh

Huh.

Erin Allmann Updyke

Yeah, isn't that interesting?

Erin Welsh

That's very interesting.

Erin Allmann Updyke

So that's all the different sort of forms of mercury and how we get exposed to them and the differences in how much of the mercury you're exposed to is going to actually make it into your body. I will also note there's a lot of other forms of organic mercury besides methylmercury, some of which are even more toxic like diethyl or dimethylmercury.

Erin Welsh

Yeah.

Erin Allmann Updyke

But in general in fish for example by far the most common one that you're gonna be exposed to is methylmercury, that's what is most common in the environment. The other forms tend to be produced in industrial settings rather than by bacteria in the environment.

Erin Welsh

Okay. Gotcha.

Erin Allmann Updyke

All right so now that we know all of that, what does it actually look like when this mercury does get into our bodies? What happens and why does it make us so sick? So again here there's a lot of complications and what I'll say up front is that if anyone remembers our lead episode, a lot of the mechanisms of how mercury causes toxicity are not very dissimilar to lead but the difference was that in lead there's kind of one very compact story, like lead binds to a specific enzyme that then blocks heme synthesis and causes anemia. With mercury because of what it does it has a much broader effect and therefore it's more difficult to pinpoint the precise mechanism if that makes sense of toxicity.

Erin Welsh

Yes.

Erin Allmann Updyke

So I'm just gonna kind of look at the broad strokes and I think that we'll understand a lot of it. So in all of the various forms once you're exposed to mercury, once it gets into our bodies it generally exists as a positively charged ion. A cation. So either  $Hg^+$  or  $Hg^{2+}$  or even methylmercury itself is a positively charged molecule. And because it's positively charged like all positively charged ions they have an affinity for negatively charged things. In our body that means proteins and some amino acids.

Erin Welsh

Uh oh.

Erin Allmann Updyke

So yeah, uh oh is right. And so lead does the same thing. Lead exists as a positive ion and binds to certain proteins. In the case of mercury though, mercury has a strong affinity for proteins and amino acids that contain two different types of residues. Sulfur groups which are called thiols and selenium groups which are called selenols. So there's two big problems with this. Number one there are some amino acids like for example cysteine which is an amino acid with two sulfurs that when methylmercury binds to cysteine it looks like another amino acid, methionine that's a neutral amino acid and is not just able to cross barriers but can be actively transported across barriers like the placenta and the blood-brain barrier.

Erin Welsh

Okay.

Erin Allmann Updyke

By amino acid transporters. So not only can this ion itself potentially cross these barriers, once it connects with cysteine it can be transported. Like, 'Oh hey! You look like methionine, come on over.'

Erin Welsh

We need you.

Erin Allmann Updyke

We're gonna use you to build this fetus or we're gonna use you and like deposit you in the brain right now.'

Erin Welsh

Oh my gosh.

Erin Allmann Updyke

So that's bad.

Erin Welsh

Yeah.

Erin Allmann Updyke

The other thing, cause that kind of tells us that's how it gets into these structures. What does it do once it's there? Like why is that so bad to have mercury instead of actually methionine?

Erin Welsh

Right.

Erin Allmann Updyke

By binding to not just cysteine but a whole suite of proteins, amino acids, and enzymes, what mercury does is it causes a cascade of downstream effects. It's basically blocks, interrupts the actions of these various enzymes or proteins. And like I said it's not just one, it's not just cysteine, there's a whole bunch of enzymes that have either sulfur or selenium groups on them. So one of the principal effects seems to be that an increase in mercury leads to a decrease in the antioxidant ability of our body. So a lot of the damage that occurs in mercury toxicity is due to reactive oxygen species. So basically mercury is blocking enzymes that normally help fix oxidative damage and it blocks their ability to do so, it's like, 'Boop, you can't fix this.' And so now there's just this free-floating reactive oxygen that can cause a lot of damage. And when you combine that with its ability to cross these important membranes like the blood-brain barrier and the placenta, you get oxidative damage in structures that can't easily be repaired.

Erin Welsh

That makes a lot of sense.

Erin Allmann Updyke

I'm glad because it took me a long time to understand it.

Erin Welsh

I mean it's really complicated and these are things I haven't thought about.

Erin Allmann Updyke

Yeah.

Erin Welsh

Like oxidative stress and so on.

Erin Allmann Updyke

I know.

Erin Welsh

That's nitty gritty.

Erin Allmann Updyke

It's very nitty gritty.

Erin Welsh

And so this is just because the mercury ion once it's in you is attracted to, it's binding to this negatively charged things and sort of replacing their function or preventing them from functioning the way they should.

Erin Allmann Updyke

Exactly.

Erin Welsh

Okay.

Erin Allmann Updyke

Precisely. Exactly. Yeah, exactly.

Erin Welsh

Wow.

Erin Allmann Updyke

And it can do that on so many different sort of proteins and enzymes. Yeah so it's very bad.

Erin Welsh

And so this is why systemic systems-

Erin Allmann Updyke

Systemic. And why so many of the symptoms that we'll see are neurologic.

Erin Welsh

Right.



Erin Allmann Updyke

Because once it gets into the brain it can kind of just stay there for quite some time, bound to these proteins and enzymes. So the symptoms in some ways do depend on the form of mercury that somebody is exposed to but what they really depend on is where that mercury goes and potentially accumulates. And so that also depends on whether the exposure is a whole bunch of mercury all at once like acute toxicity or a smaller amount of mercury over a long period of time or chronic toxicity. So I'll kind of go through very briefly organ system by organ system because since we're exposed to these different forms of mercury in different ways they tend to have most effects on certain organs if that makes sense. But the truth is that any of these forms of mercury can potentially cause any of these types of symptoms, right, because once it's in your body it all acts relatively similarly.

Erin Welsh

Right, that makes sense.

Erin Allmann Updyke

There are still some subtle differences but... All right so let's talk about our lungs first. You're most likely to be exposed to mercury in your lungs through mercury vapor which is mostly elemental mercury. This happens most often in industrial or occupational settings. And inhalation of mercury vapor especially a large amount, like more than 1000 micrograms per cubic meter of air can cause massive interstitial pneumonitis. So this means inflammation in the lining surrounding, like the spaces inbetween your cells of your lungs. Because this mercury, you can kind of think of it as just ripping through the lining of your lungs.

So you'll have all this inflammation which will lead to a pretty severe cough because of all this fluid, a lot of chest pain because that fluid is gonna irritate the whole lining of your chest. Difficulty breathing, this mercury does distribute throughout your body so it's common to have a rash that appears on the skin. People often have a metallic taste in their mouth and might feel nauseous or might vomit, they might start bleeding from the gums which is a pretty common symptom of a lot of different forms of mercury poisoning, sort of gingivitis. And then elemental mercury is removed from the body mostly through the kidneys so we can see kidney failure.

Erin Welsh

Okay, yeah.

Erin Allmann Updyke

But often with large enough exposure this is fatal, this is a very fatal form of exposure and the death tends to be due to respiratory failure especially in the case of children who are exposed to large quantities of elemental mercury vapor.

Erin Welsh

What is a large quantity?

Erin Allmann Updyke

So in general these acute symptoms would happen at pretty high concentrations like above 1000 micrograms per cubic meter. I tried to get a sense of like how many grams of liquid mercury it would cause to get that but I couldn't get that number I think in part because it depends on are you heating it or is it just at room temperature and all of that. But even at chronic, like lower levels of exposure between 25-100 micrograms per cubic meter of air, even those levels have been shown to be enough to cause chronic symptoms.

Erin Welsh

Right.

Erin Allmann Updyke

Which tend to be more neurologic and we'll talk about the neurologic symptoms in just a bit.

Erin Welsh

It's hard to picture those amounts but-

Erin Allmann Updyke

I know. For a lot of this, even in fish it's like I have no idea how much mercury that is. One number that I saw really commonly was that... So in a mercury thermometer there's anywhere from like 0.5 to 3 grams of mercury so often average is used as 1 gram of mercury in a thermometer. And you'll see the stat that 1 gram of mercury can cause contamination of a 20 acre lake.

Erin Welsh

That's a big lake.

Erin Allmann Updyke

That's a big lake. It's not a huge lake but it's a lake. And that stat is true but with the caveat that that number comes from the annual deposition of mercury in a lake in Minnesota, I believe it was Minnesota, where about a gram of mercury was deposited over the course of a year and those fish then had high levels of mercury, like unacceptably high levels. So it's true but it's not like if you just took a thermometer and broke it and dumped it in a lake then you would contaminate all those fish because it's a process that takes time and if you just dumped a bunch of mercury most of it wouldn't actually find its way into the fish.

Erin Welsh

Right.

Erin Allmann Updyke

But over time that amount of mercury would in fact work its way up the food chain. Does that make sense?

Erin Welsh

Okay. That makes sense, yeah.

Erin Allmann Updyke

So then let's move onto the GI tract. Inorganic mercury is probably one of the most, maybe not the most common but it's associated with pretty strong GI symptoms if you are exposed. But again any form of mercury can cause symptoms like this. So GI symptoms are things like very severe abdominal pain, nausea, vomiting, bloody diarrhea. I did find that in the case of inorganic mercury, ingestion of 1 gram or more can be lethal either due to kidney failure or cardiovascular collapse because again even though only about 10% of it is absorbed, if that then makes it into your heart it can cause damage there as well.

Erin Welsh

Okay.

Erin Allmann Updyke

The other thing too is that inorganic mercury is something that can be present - in most places this is not legal - but it can be present in skincare or makeup products, especially skin lightening products. So that is very dangerous because inorganic mercury can be readily absorbed through the skin much better than the GI tract. And then of course there is the nervous system symptoms which we most strongly associate with methylmercury poisoning or what we heard about in our firsthand account, Minamata disease. But again especially in terms of long term chronic exposure to low levels of mercury vapor or other forms of mercury can certainly cause these same neurologic effects. And just like with the other forms, exposure to a very large dose, an acute poisoning is often fatal. But what's much more common is that people are exposed to low level or moderate level doses over longer periods of time. And then this methylmercury is able to build up in the nervous system and cause these effects.

So in adults or children who are exposed to methylmercury these symptoms can take months to manifest. And what tends to happen is that the peripheral nervous system is largely involved. But then the central nervous system, so like the brain, also can then become involved. So early it might be things like sensory impairments, not being able to feel things the way that you could before or paresthesias which are those feelings of like a burning sensation or a tingling, maybe a numbness or like a pinprick sensation, any of those. Tremors like we heard in our firsthand account are very common. And those are all mostly peripheral nervous system effects. But then as it affects your central nervous system you can have ataxia which is difficulty walking because you can't coordinate your limbs, this numbness and weakness, you can have also rigidity in your muscles because the nerves are not firing correctly, you can have dysarthria which is difficulty speaking because you can't coordinate the muscles of your mouth. You can also have things like memory loss, dementia, blurry vision or loss of vision, loss of hearing.

So this can affect any part of the nervous system and so especially in the case of large exposure or continued chronic exposure, this can lead to death in kind of any number of ways from respiratory collapse cause you've impaired the nerves that are involved in breathing or in the brain, like you respiratory drive. It can lead to cardiovascular collapse. Even though methylmercury is primarily not excreted by the kidneys it still does have major effects on the kidneys so it can lead to renal failure. It's a pretty devastating disease.

Erin Welsh

It is. Yeah, absolutely devastating.

Erin Allmann Updyke

Yeah. And then of course methylmercury also affects the developing nervous system of a fetus and so it can cause abnormal development in a number of different ways. It can lead to congenital blindness or deafness, it can lead to an inadequately developed brain or an incompletely developed brain, so microcephaly. It can lead to difficulties with walking or speaking, it can lead to a syndrome that looks a lot like cerebral palsy which is like exaggerated reflexes, involuntary movements of the limbs, limbs are often rigid. Things that look kind of very similar to what exposure to methylmercury would look like in an adult but that happened congenitally essentially. And that's of course if the baby survives because large quantities of methylmercury exposure can also cause fetal demise as well and pregnancy loss. So it's pretty horrific.

Erin Welsh

Yes.

Erin Allmann Updyke

That's all I have for the biology Erin, it's a downer of an ending.

Erin Welsh

I mean it's a reality though.

Erin Allmann Updyke

It is, yeah. And the thing that's I think just so much worse, I don't know if that's even the right word but there's not really anything that we can do especially in the case of methylmercury poisoning. If exposure is from metallic mercury vapor you can use chelators which are essentially a way to help bind that mercury and help us excrete it faster. But chelators don't really work to treat inorganic or especially organic mercury poisoning. So there's not much that you can do and especially in the case of this neurologic damage, it's permanent. You've destroyed those neurons.

Erin Welsh

Right. Yeah, yeah.

Erin Allmann Updyke

Yeah. So Erin, how in the heck did we get here to this point?

Erin Welsh

I mean I probably won't be able to answer that question but I will at least touch on some I think pretty important things in the history of mercury.

Erin Allmann Updyke

Okay.

Erin Welsh

Let's take a quick break first.

TPWKY

(transition theme)

Erin Welsh

So like you Erin I also got overwhelmed when I first started researching this because this is a huge topic not just in the biology but also in the history. And I say this for so many episodes.

Erin Allmann Updyke

I know. I know, we're so broken records.

Erin Welsh

I know, I know. But I mean I will say that like for mercury there are many different ways that you can tell this story. There's so many different things you could focus on. Like you could focus on the role of mercury in mining, the impact that mercury has had on trade, mercury in chemistry, in alchemy, in religion, occult practices. And then there's of course the role that mercury has played in the history of medicine. So like the development of the mercury thermometer and how crucial that was, mercury used to treat syphilis and gonorrhea and other conditions.

Erin Allmann Updyke

We've talked about that.

Erin Welsh

We've talked about that. And mercury used in dentistry. I mean it just like goes on and on. And then there's the darker side of mercury and its toxicity especially in occupational exposure or industrial exposure, so miners experiencing symptoms due to chronic exposure, hatters exposed to mercury vapors giving rise maybe to the Alice in Wonderland Mad Hatter character. And then of course there's these many accidental and intentional cases of mercury poisoning through ingestion. And the story of mercury is not just super broad, it's also quite deep, right, because humans have been working with mercury since the early days of civilization, using it for all of these things I've already mentioned. It got its name after all from the Roman god Mercury who was the Greek god Hermes. I couldn't resist throwing a little bit of Ancient Greek or Ancient Roman trivia in here.

Erin Allmann Updyke

We've gotta have at least a touch.

Erin Welsh

At least a touch. But instead of trying to tackle the entirety of mercury and its role in human culture and society, I decided to focus specifically on one particular area and that is Minamata disease and the horrible circumstances surrounding it. And if you want to know more about these other areas of mercury that I mentioned, there is a book that I'll mention again in the sources section called 'Mercury: A History of Quicksilver' by Leonard Goldwater and it's full of anecdotes about its chemical and industrial history.

Okay. But Minamata. So I decided to focus on this incident in particular cause it's a hugely important topic not only in the history of Japan but also in the general history, the global history of industrial contamination and putting the interest of corporations above the health and wellbeing of individuals. And it's also still extremely relevant for today in its lessons on the human costs of industrialization and pollution but also on the power of grassroots movements and raising awareness and achieving maybe not justice but accountability at least in some measure. And I'm really worried that I'm not gonna do this story the justice it deserves but at the very least what I hope will happen is that you will become interested enough that you'll wanna check out more of these wonderful sources that I will list at then end of the episode because they are really, like there is so much more to the story and I really want people to read more about it.

Okay. Minamata is a small coastal city in the very southwestern tip of Japan. And today if you do a Google Image search of Minamata you won't find many pictures of the beautiful Minamata Bay and the shimmering Shiranui Sea and the lush green mountains surrounding the city. Instead you'll find images from one of the worst environmental disasters the world has ever seen. And this is the legacy left behind by the Chisso Corporation still in operation today. The company first set up shop in Minamata in 1908 producing fertilizer but then in 1932 it expanded its operations when it began to produce acetaldehyde which importantly uses mercury sulfate as a catalyst. Over the next few decades Chisso ramped up production of acetaldehyde producing thousands or tens of thousands of tons each year. And all of these tons of acetaldehyde meant also the production of thousands of tons of waste.

And that waste which was not great to begin with became incredibly deadlier when in 1951 the Chisso Corporation changed the co-catalyst in this reaction to ferric sulfide which led to the production of mercury waste which was much more readily transformed into methylmercury when it was dumped into the sea next to Minamata where there were lots of bacteria to take up that mercury and turn it into methylmercury. And so like you talked about, Erin, methylmercury is an organic compound, so it can be readily absorbed by plants and animals and so all of this mercury waste that was being unloaded into the water wasn't sitting harmlessly on the seafloor, it was being immediately turned into methylmercury and then taken up by plants and then the plants were eaten by fish and then bigger fish and it's the classic story of bioaccumulation, right.

If you were living in Minamata in the 1940s or the 1950s, if you weren't working at Chisso there was a pretty good chance that you either fished or farmed for a living and no matter where you worked there was an even better chance that locally caught fish and shellfish and seaweed constituted a pretty substantial portion of your diet. And so as this toxic mercury continued to be dumped into the sea outside Minamata and then be transformed into methylmercury and then accumulate in the plants and fish living in it, it of course found its way into the diet of the residents of Minamata. The first signs that anything was wrong came pretty early on right around 1951. Some fish seemed to be just floating in the bay and could be easily caught by hand. Barnacles stopped appearing on boats near the factory dumping grounds and seaweed began to float to the surface, its color appeared to be fading and its roots became more brittle. Birds especially crows began to fall from the sky, crashing into the sea or the ground dead and you could snatch a sea bird easily just like with your bare hands.

Erin Allmann Updyke

That's not good.

Erin Welsh

No. And by 1953 things had gotten worse. More fish began acting strange, swimming in a bizarre way in the thick, greasy, stinking patches of water outside the factory that people compared to turning the sea into a swamp it was so thick. And people were finding their nets emptier and emptier. Seaweed began to disappear and you couldn't find shellfish anywhere close to the shore. But the most noticeable change, the thing that would really kind of sound the warning bells was the cats of Minamata. People had started noticing that their cats had trouble moving, they seemed super uncoordinated, they would suffer convulsions, they salivated profusely, and they would bring their noses close to the ground, almost looking like they were trying to do a headstand by kicking their back legs up. They ran round and round, running into rocks or trees with many just jumping into the sea and drowning. Soon there were nearly no more cats left in the area. Like for example in 1954 in one hamlet, 100 of the 120 cats died within two months.

Erin Allmann Updyke

What?

Erin Welsh

Yeah. The loss of cats was devastating obviously not just because they were pets but because cats also performed an invaluable service by killing mice and rats who would damage fishing nets by chewing through them. And so when all the cats started to die the mice and rat populations exploded making it impossible to keep a fishing net intact. But did it even matter because there were almost no fish to even fill these nets with. Between 1953 and 1955 fish catches went from 490,000 kg a year to about 1/3 of that, 183,000 kg a year.

Erin Allmann Updyke

Whoa.

Erin Welsh

But it wasn't just the fish and the birds and the seaweed and the cats that started showing worrying changes, it was also the residents of Minamata. Several people began developing problems walking or talking or getting numbness in their fingertips or shaking in their limbs, tunnel vision, and they went to the hospital to receive a diagnosis of anything ranging from Japanese encephalitis to alcoholism, anything other than mercury poisoning, before many of them died. But it took a few years of this before anyone recognized that what they had on their hands was not some Japanese encephalitis or whatever, it was an outbreak of an unknown, debilitating and often deadly disease.

In 1956 two young girls, sisters, were brought to the hospital by their mother after they began showing trouble walking and talking. And the mother of the girls told the doctors that their neighbor who was another young girl had also been showing the same symptoms. So the doctors went to investigate and they found that they actually had at least 8 people with the same symptoms, with the same disease which was enough for them to declare to the public health office that, quote: "This is an epidemic of an unknown disease of the central nervous system." And not long after this declaration more cases started appearing with some families entirely affected.

Erin Allmann Updyke

Geez.

Erin Welsh

But there was such a stigma surrounding it that people stayed behind doors as their neighbors shunned them. For some people the disease came on rapidly, strong, healthy fishermen yesterday woke up today unable to stand on the boat and cast his net. Soon he would be in the hospital suffering from convulsions and bloody fingertips as he rips off his nails by scratching at the walls. Horrifying and terrifying don't even begin to cover it and you can imagine how neighbors and friends and family nervously watched for signs of the disease in themselves probably. May 1st, 1956 marks the date when the mysterious disease affecting the residents of Minamata was officially discovered. But the doctors didn't yet know what the disease was or what was causing it which meant that they could do nothing to prevent it.

City authorities went to the homes of people who had come down with this disease and they ordered them out, forcing some into isolation so that they could disinfect, like spray the entire house which only furthered the fear and stigma associated with it. After interviewing the patients many of which were from fishing families the people in charge of the investigation came to the conclusion that it was likely something from the seawater. But they weren't sure exactly what it was although immediately several heavy metals were proposed. But these surveys tended to be super focused which kind of led to this picture of Minamata disease as just one thing, like the most extreme cases. And it overlooked the people who had less severe symptoms which ultimately meant that they weren't recognizing the extent of the exposure both in terms of the number of people impacted and the scope of disease symptoms but also how widespread it could be geographically.

Erin Allmann Updyke

Right.

Erin Welsh

But it's also not as though narrowing down the cause was like super duper easy. The Chisso Corporation was dumping a lot of chemical waste into Minamata Bay and so trying to figure out which of the possible, I think at the beginning of the investigation there were like 64 possible poisons proposed.

Erin Allmann Updyke

Oh geez.

Erin Welsh

And so figuring out which one of those was causing symptoms wasn't necessarily this easy thing to do. And the factory certainly didn't help narrow down things. In one of the books I read for this the author describes a 4 stage model for all pollution events. First people become aware of the problem. In Minamata this happened in May 1956. Second they begin to search for the cause which does take some time usually. Third the polluter proposes or supports alternative theories to draw attention and responsibility away from themselves and so then the public becomes confused as to who to believe.

Erin Allmann Updyke

Okay.

Erin Welsh

Fourth, all of these theories or hypotheses compete with and then neutralize each other so that still no one knows what to believe.

Erin Allmann Updyke

Oh gosh.

Erin Welsh

And so whenever mercury was proposed the Chisso Corporation was there to say, 'No, we actually think it's red tide,' or, 'No, we don't dump any mercury at all, it's impossible,' or, 'No, it's actually mercury from the agriculture,' whatever. And they also directly tried to prevent research linking the disease to the waste that they dumped into the sea. Like in one instance they bought up all the fish in the markets so that a researcher from the NIH in the U.S. couldn't take any back to conduct research on.

Erin Allmann Updyke

Oh geez.

Erin Welsh

Yeah. And in 1958 they changed the dumpsite from Minamata Bay, from the sea, to the river to try to mislead the investigations that were going on at the sea dumpsite which actually led to only more widespread exposure because people started showing up with Minamata disease like farther away.

Erin Allmann Updyke

Yeah if anything that's just gonna show more support like if you move your dumpsite then you're gonna move where people get sick.

Erin Welsh

Yeah.

Erin Allmann Updyke

People are gonna get sick in your new dumpsite. That wasn't good forethought on their part.

Erin Welsh

Right but like if there were forethought then maybe there would've been no methylmercury poisoning in the first place.

Erin Allmann Updyke

What a concept, Erin.

Erin Welsh

What a concept. But one of the most egregious things they did was they hid the results of experiments that the Chisso hospital doctor had done which conclusively showed that they were responsible for the waste. So he was feeding cats different waste and then there was this infamous cat #400 who developed symptoms of Minamata disease after being fed waste from the acetaldehyde process. But when he brought these results to the company, the company ordered the results to be destroyed or hidden and they stopped and said no more experiments, you will not have access to anymore of this acetaldehyde waste.

Yeah. But despite Chisso Corporation's best efforts, starting in 1959 methylmercury produced as a result of this acetaldehyde production was finally pinpointed as the cause. Mercury was found in the waste that they produced, it was found in the seafood in Minamata, that seafood was found to cause symptoms in cats in experiments, and it was found in the people suffering from the disease. The researchers who tested water or hair for mercury made measurement after measurement, they were like there's no way that these numbers can be right because they're off the charts. The amount of mercury near the factory waste outlet was found to be over 2000 parts per million.

Erin Allmann Updyke

Oh.

Erin Welsh

Yeah, that's 2 kg per ton which is twice the amount needed for a mercury mine like where you specifically mine for mercury.

Erin Allmann Updyke

So the thing is because of bioaccumulation even very low levels of mercury in the environment can lead to very high levels in fish so having that high of levels in the environment is terrifying.

Erin Welsh

It is, yep. Yeah. And there was so much mercury that they actually ended up establishing like a subsidiary to reclaim the mercury in the waste because it was valuable.

Erin Allmann Updyke

Oh dear.

Erin Welsh

Uh huh. Hundreds of people were found to have greater than 50 parts per million in their hair which is the level at which neurological symptoms can develop. And one woman was found to have 920 parts per million.

Erin Allmann Updyke

Oh dear.

Erin Welsh

Yep. And you might think or at least hope that given these solid links between acetaldehyde waste and Minamata disease there would be some sort of acknowledgement or attempt to right the wrongs by the Chisso Corporation. But also if you're a listener of this podcast you know that history is full of disappointing, to say the least, people and corporations and this is one of them.

Erin Allmann Updyke

Yeah. It really just feels like these...

Erin Welsh

It's really hard to wrap your brain around.

Erin Allmann Updyke

Yeah.

Erin Welsh

Because when I was doing this I was reminded of many of the things that we've talked about that I think in particular thalidomide-

Erin Allmann Updyke

Yeah, thalidomide.



Erin Welsh

And the solid links, the knowing, and then the refusal, denial, denial.

Erin Allmann Updyke

Right.

Erin Welsh

Like to what end?

Erin Allmann Updyke

To what end? I do not comprehend.

Erin Welsh

I know. I don't know how you can have a conscience, a soul and make these decisions.

Erin Allmann Updyke

Ever again. Yeah, I don't...

Erin Welsh

Yeah. But the Chisso Corporation took great issue with these findings and they continued to try to undermine them. They produced pamphlets to discredit the findings and the university researchers who had compiled them saying they're not qualified for their jobs. And the sad thing is Chisso had a lot of the residents of Minamata on their side along with the local and regional government. The factory had been seen by many as the town's economic savior especially in the years following WWII during the economic recovery period. And about 25% of the jobs in the town were somehow linked to Chisso or to Chisso and their different subsidiaries. And in the face of these links between Minamata disease and the factory waste, the corporation kept making these subtle threats like, 'Oh we're gonna shut down and move somewhere else if people don't drop their complaints. Like this is proving to be very problematic for us.' But it wasn't just the people affected by methylmercury poisoning that had issues with Chisso, it was also the fishing co-ops who had all but lost their source of income as fish populations declined something like 90% over the 1950s.

Erin Allmann Updyke

Oh my gracious.

Erin Welsh

Yeah. And also the sale but not the catching of fish from Minamata was banned so like you could still catch fish but to what end? Well because what would happen is that if they banned the actual fishing itself then Chisso would have to pay more because it'd have to show that they took the livelihoods. Anyway and so these fishing co-ops also demanded recognition and compensation from Chisso but the public kind of turned against them after there were some riots or some sit-ins that turned violent. And this had the effect of also stigmatizing the people with this methylmercury poisoning who were either ignored or harassed for fighting Chisso. Finally though at the end of 1959 the fishing cooperatives and the people with Minamata disease won small victories as Chisso finally made some payments. They did not however take responsibility for the poisoning, they just said, 'Oh no, these payments are like a charitable gift from a caring neighbor.' Yeah.

Erin Allmann Updyke

Oh gosh.

Erin Welsh

And these gifts showed how much the company believed a life was worth.

Erin Allmann Updyke

Oh no.

Erin Welsh

They agreed to pay adults 100,000 yen which was \$278 per year and children 30,000 yen per year, \$83 and 20,000 yen or \$56 in funeral expenses. But they required a certification committee to decide who would be eligible for the money. And the company asked to include a clause where quote: "Even if in the future it is determined that the cause of Minamata disease is the factory's waste water, the patients will make absolutely no further demands for compensation money."

Erin Allmann Updyke

What?

Erin Welsh

Mm-hmm. Beyond the pale, I mean I don't...yeah. And they also made small payments to these fishing co-ops and they importantly, their big public image thing was they built this pollution control center which was supposed to remove the mercury from the waste that they produced. It did not. Like not at all, it was just for show.

Erin Allmann Updyke

What?

Erin Welsh

Yeah.

Erin Allmann Updyke

What's the point, Erin?!

Erin Welsh

This was the cost of progress in their eyes, I think. I don't know. At this point in time, so 1959, the number of people with confirmed Minamata disease was in the dozens but the next 10 years would show just how tiny the tip of the iceberg that was. After the so-called sympathy payments in 1959, I think that the Chisso Corporation thought or at least hoped that the people affected by the mercury poisoning would just shut up, take that tiny bit of money, and just go. But they didn't.

This decade from 1959 to 1968 is sometimes called the decade of silence or the decade of isolation in the history of Minamata disease but that's kind of a mischaracterization. If there was silence it wasn't from the people who were suffering from the disease, it was from the government or the Chisso Corporation and also from many of the non-affected citizens willfully ignoring this massive environmental disaster. But no matter how much they closed their eyes or plugged their ears the problem wouldn't just go away. Even though the payments had been made and the ridiculous waste cleanup program had been constructed and no one was eating fish anymore, the disease itself didn't go away.

Erin Allmann Updyke

Yeah.

Erin Welsh

It appeared to be spreading. And part of this was when doctors began to recognize congenital cases of Minamata disease in the early 1960s. Since the early 1950s and into the 1960s rates of miscarriages, of stillbirths, diagnoses of cerebral palsy, and other congenital defects had soared through the roof. For example the normal background rate of cerebral palsy was estimated to be about 0.2-0.6%. But in affected areas that had gone up to 7.46%.

Erin Allmann Updyke

What?

Erin Welsh

Uh huh. Uh huh. Yeah. Doctors began to suspect that these children had been poisoned by mercury in utero and hair samples, breast milk samples, and umbilical cord samples all supported this. Another fight then happened to get these congenital cases of Minamata disease to be recognized and eventually they were but again only for those tiny payments. But throughout the 1960s other things were happening on a national scale that would help turn the tide for the people with Minamata disease. So like I said, in the 1950s especially once Chisso Corporation's role in the poisoning was made clear, the victims of the mercury poisoning didn't receive a whole lot of public sympathy. But in the 1960s three other major pollution cases had come to light. Air pollution in Yokkaichi City leading to a lot of asthma, cadmium poisoning in Toyama Prefecture, and the second Minamata disease is Niigata Prefecture north of Tokyo, so it was like basically Minamata take two from another factory also leading to methylmercury poisoning.

Erin Allmann Updyke

Oh.

Erin Welsh

These three along with the mercury poisoning in Minamata are called the Big Four Pollution Cases and several lawsuits had already begun for the other three in the 1960s which then gave hope to the people affected by Minamata disease that maybe he could finally get some small piece of justice. And in 1968 the government announced their official findings that the Chisso Corporation was responsible for producing the waste that led to widespread methylmercury poisoning in and around Minamata. And it was only in this same year in 1968, 12 years after the disease was first recognized that the Chisso Corporation finally stopped dumping mercury into the sea outside Minamata. They did it for 12 years.

Erin Allmann Updyke

After it was-

Erin Welsh

They continued to pay people.

Erin Allmann Updyke

Right.

Erin Welsh

But said, 'Oh we put this pollution cleaner upper and so there could not possible be a case after 1960 once we built this thing.'

Erin Allmann Updyke

Erin.

Erin Welsh

Uh huh. That's 12 years of knowingly poisoning human beings. Like that was the price of progress. It's very hard.

Erin Allmann Updyke

Yeah.

Erin Welsh

These sympathy payments were not seen as accountability or responsibility, they were just damage control. Like how much money do we need to throw at this? What's the least amount of money we can throw at this to make the problem go away?

Erin Allmann Updyke

Right. That's what I feel like it always is.

Erin Welsh

And the people impacted by the disease were not going to accept that anymore. With these other pollution events and the incredible grassroots work done by people such as Ishimure Michiko who's the person who wrote the book 'Paradise in the Sea of Sorrow' which is by the way one of the best books I've ever read I think.

Erin Allmann Updyke

Oh wow.

Erin Welsh

Like it was absolutely... Her writings are so beautiful and so impactful and I just want everyone to read it, it's unbelievable. And also the work of several photographers like Kuwabara Shisei, Shiota Takeshi, Miyamoto Shigemi, and also Eugene and Aileen Smith who helped to bring Minamata disease to wider attention and the struggle for recognition by the company as to what they did. And I also wanna especially shout out - cause I learned this in the research for this episode - that Eugene and Aileen Smith who brought this international recognition to Minamata disease, there's actually a new movie called Minamata that came out in 2020.

Erin Allmann Updyke

What?

Erin Welsh

I couldn't find it streaming anywhere yet, about Eugene Smith who was a photographer for LIFE who basically invented the editorial photo essay and his and Aileen's book titled 'Minamata' is beautiful and incredible and it's like groundbreaking.

Erin Allmann Updyke

Wow.

Erin Welsh

Anyway all this is to say that by the time that 112 patients and family members had filed a suit against the company in 1969, they had a lot more public support than they'd previously had. And it took a few years but eventually they did see success in court. It wasn't perfect but it did force the Chisso Corporation to pay more and it also held them responsible legally for the poisoning. It legally said that they had shown negligence in dumping between 224-600 tons of mercury estimated.

Erin Allmann Updyke

That is not only massive amounts but a massive range that is terrifying.

Erin Welsh

Right. So 224 is definitely like, those are not the Chisso Corporation's estimations by the way but it is thought to be at least 224.

Erin Allmann Updyke

Ugh.

Erin Welsh

And so when you said that thing about the one drop of mercury or like that little bit of mercury from a thermometer...

Erin Allmann Updyke

Yeah.

Erin Welsh

Yeah. But there would still be a certification committee and this committee excluded a lot of people who had less severe symptoms, like how didn't display the classic methylmercury poisoning symptoms. But still it was a big step forward. It gave the people who had Minamata disease and their families some relief and a sense of dignity, it allowed them to not fight constantly to get the Chisso Corporation to acknowledge that what they did was wrong but to actually then have the power to say, 'Okay yes, what you did was wrong. Now what can you do to make it at least a little bit better? You'll never make it right but to make it a little bit better.'

Erin Allmann Updyke

Right.

Erin Welsh

And I'm gonna wind down the history here, maybe rather abruptly but I do wanna be clear that the story of Minamata disease is not over. The Minamata Bay was declared cleaned of mercury by I think 1994 but today many of those with congenital Minamata disease are at an age where they need increasing amounts of support and care and their parents who have typically provided that care are also aging and less physically able to do that. Many people are still unregistered, they haven't been able to get certified by these committees and so they don't have any payments from the Chisso Corporation to help them with their medical issues and also many people are still unsatisfied with the inaction and lack of accountability from the government and have continued to fight for recognition. In total 2265 people have been officially certified of whom 1784 have died and 10,000 have received financial compensation from Chisso.

More recently it has been suggested that called Minamata disease a disease rather than a criminal poisoning hides the truth, it doesn't place the responsibility at the feet necessarily of the Chisso Corporation. The history of this criminal mercury poisoning by the Chisso Corporation in and around Minamata has led to the creation of an entire field of study. It has inspired plays, poems, and songs, it was impactful in the democratization of Japan, it helped turn the tide for corporate accountability, and it revealed this power of grassroots movements. And we cannot afford to ignore or forget what happened in Minamata because it's going to keep happening. Maybe it won't be methylmercury poisoning although it probably will also be that and there definitely have been instances of mercury pollution since Minamata but there's also a good chance it could be something similar. Like what about climate change and the large scale destruction of our planet? What is the true cost of progress?

There's a great quote from the book 'Minamata' by Eugene and Aileen Smith: "The morality that pollution is criminal only after legal conviction is the morality that causes pollution." This is as relevant today as when it was first published back in 1975. I can't emphasize enough how so many corporations are not being held accountable for what they're doing to the planet. And so I really, really encourage everyone to learn more about his, about Minamata, read 'Paradise in the Sea of Sorrow' by Ishimure Michiko or 'Minamata' by Timothy George or the photo essay book by Eugene and Aileen Smith or watch the documentary 'Minamata: The Victims and their World' because there is so, so much more to the story than what I've gone through here. But anyway, I think Erin that I'm ready for you to tell me what's going on with mercury and mercury poisoning today.

Erin Allmann Updyke

I would love to after the break.

TPWKY

(transition theme)

Erin Allmann Updyke

So I try always in these sections to talk about numbers, right. Like in this case it would be do people still get mercury poisoning? How many? I couldn't find numbers on this, Erin.

Erin Welsh

I mean...

Erin Allmann Updyke

The only number I could find... I found a couple. We'll still talk numbers, don't worry. The World Health Organization estimates that in subsistence fishing communities between 1.5-17 - which is a huge range - of every 1000 children have some kind of cognitive impact because of the consumption of mercury-contaminated fish.

Erin Welsh

Wow.

Erin Allmann Updyke

Yeah. I don't know, that number is from World Health Organization like mercury fact sheet website, I don't know exactly where that number came from but that's the number that they cite. If we look at the potential for occupational exposure which we know is great in certain industries especially in artisanal and small scale gold mining, I found a paper from environmental health perspectives from 2014 that was a review on the health effects of mercury in these artisanal and small scale gold mining communities. They cited that globally 15 million people participate in this type of gold mining across 70 different countries which is a way bigger industry than I realized.

Erin Welsh

Yeah.

Erin Allmann Updyke

And they didn't have numbers like what percentage of people have signs of mercury poisoning or anything like that but they did say that... This paper was kind of a review of papers that have looked into it and mercury exposure at very high levels is found and causing potential health problems. So it's still not numbers but at least you get a sense of the potential scale. But the thing is that it's not just occupational exposure, right, and it's not just subsistence farming communities, everyone is exposed to mercury if you've ever eaten a fish or a shellfish, if you've ever eaten grain you've probably been exposed. It's everywhere. So what I wanna focus on instead is how much mercury are we talking about in the environment and where is this mercury coming from?

So I mentioned at the very, very top like three hours ago in this episode that mercury is found naturally in the earth's crust. And there is a natural mercury cycle where mercury is released from things like geothermal vents, from volcanic activity, from biomass that's burned during fires. This happens normally and then this mercury is released into the atmosphere, it's deposited in the soils or the oceans or the waterways where it of course can become methylated and it can become part of the biomass or become part of the soil deposits and eventual fossil fuels, etc. Right? That's a natural cycle like the water cycle, the carbon dioxide cycle, all of our cycles. But just like the carbon dioxide cycle the amounts of mercury currently in our atmosphere and being released into our atmosphere to become a part of this active cycle rather than trapped beneath the earth's crust are vastly higher than they have been ever because of humans. Unsurprisingly the sources of increased mercury concentrations in the atmosphere are anthropogenic.

So let's put some numbers on it. If you check out the EPA website which reports data from the U.S. and all of the industries that report mercury emissions and all other emissions to the U.S., the EPA has reported a 73% decrease in airborne emissions of mercury from 2007-2019 which if you look at that on a national level you're like that's awesome, that's a huge decrease. But the thing about something like mercury or carbon dioxide is that we can't look at things like environmental pollution on a country or a national level. This is a global phenomenon with global consequences because mercury released into the atmosphere can travel thousands of miles before being deposited via rainfall into our soils and waters where it can continue to travel throughout the water cycle across the globe, be methylated by bacteria, uptaken by plants into our food chain, those fish can then travel across the globe and then once a fish is caught for consumption it can be shipped anywhere around the world.

Erin Welsh

Yep, yep, yep.

Erin Allmann Updyke

So this is a global issue. So how are we doing globally? A U.N. report from 2018 estimated about 2200 tons, that's 2200 tons of global emissions of mercury in 2015. This is an increase of 20% from 2010.

Erin Welsh

Okay.

Erin Allmann Updyke

When we look at what the contributors are, coal burning and other fossil fuel burning accounts for about 24% of all of the total global emissions. The largest overall percentage, 37.7% is contributed by artisanal and small scale gold mining. So this presents issues not only for the people who are being exposed to this mercury vapor during that small scale gold mining but also on a large scale as well. And overall human activities have increased the total atmospheric mercury concentrations by 450% from like pre-industrial levels.

Erin Welsh

It's very difficult to wrap your brain around.

Erin Allmann Updyke

It really is because just like with climate change and carbon dioxide, the amount of mercury that we've already put into the environment, the atmosphere, the soils, the waters, it hasn't made it all into the food chain yet. So decreasing our emissions now will still take years to actually show like a beneficial effect or a decrease in total mercury.

Erin Welsh

Yeah.

Erin Allmann Updyke

So it's a lot, it's such a bigger issue than I realized, Erin. I had no idea that there was so much mercury being released by things. I didn't know that.

Erin Welsh

I mean I didn't either. You could do an entire podcast, multiple seasons on mercury for sure.

Erin Allmann Updyke

Yes. Speaking of too much to cover, a whole topic I didn't even get into which I'll just very briefly mention is something we actually touched on what feels like a million years ago in our vaccines episodes in Season 2 and that's thimerosal. So thimerosal is a mercury compound that is an additive that's been used in various multi-dose vaccine vials as a preservative. Mercury has been used as so many things, antiseptic, antimicrobial, and so thimerosal is used as a preservative to prevent contamination when somebody has to introduce multiple needles into vials multiple times to draw up vaccine doses.

So thimerosal is ethylmercury or at least it's broken down into ethylmercury in our bodies. So it's an organic mercury compound but it is not methylmercury which is what we find in fish for example. Methylmercury is 1 carbon atom and 3 hydrogen bound to mercury. Ethylmercury is 2 carbon atoms, 5 hydrogens. So back in like 1999 the American Academy of Pediatrics recommended in the U.S. reducing or eliminating the use of thimerosal in vaccines in kids because of data about the accumulation of methylmercury in tissues. And they thought that for some kids of certain sizes the dosages would exceed methylmercury recommended safe dosages. So in the U.S., the U.K., and the E.U. and a lot of places thimerosal isn't really used in childhood vaccines at all, it's been eliminated since 2004 but it is still an important preservative in vaccines in other parts of the world, it's still used in some vaccines in the U.S. But this data importantly was not from ethylmercury, it was from methylmercury and it turns out that ethylmercury, once we studied it, is eliminated from the body a lot more readily than methylmercury is, so it doesn't actually accumulate the same way.

And so since then because of all this controversy surrounding thimerosal there have been a lot of large scale epidemiological studies, none of which have shown major or long term neurodevelopmental effects of thimerosal in vaccines. There's a lot more to that story but that's all. I wanted to just mention that it exists and it's a different form of mercury than what we find in fish and than what causes Minamata disease for example. So that's mercury or at least some small slices of it.

Erin Welsh

I was gonna say I feel like we've covered a lot of ground but there's still a lot out there.

Erin Allmann Updyke

We broke the thermometer and just spilled a few drops out and there's a lot left in there.

Erin Welsh: There we go.

Erin Allmann Updyke: Okay, anyways.

Erin Welsh: Let's clean that up though.

Erin Allmann Updyke: Clean it up and don't vacuum it. Sources?

Erin Welsh: Sources. I pretty much have already mentioned mine but I will briefly just go through again the titles. So 'Paradise in the Sea of Sorrow', 'Minamata: Pollution and the Struggle for Democracy in Post-War Japan', 'Toxic Archipelago: A History of Industrial Disease in Japan'. And then 'Minamata' and then again that 'Mercury: A History of Quicksilver' book.

Erin Allmann Updyke: I had a number of different sources a lot of which go into way more detail than I did on the specific mechanisms on the toxicity of mercury. So if you'd like to read a lot more we'll list all of our sources on our website [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com) under the EPISODES tab.

Erin Welsh: We sure will. I wanted to give a huge thank you and shout out to Emily who helped me with the sources for Minamata disease. They were so helpful, I appreciate it so much, it was so great to email back and forth with you.

Erin Allmann Updyke: Thank you also to Bloodmobile for providing the music for this episode and all of our episodes.

Erin Welsh: And thank you to the Exactly Right network of whom we are a proud member.

Erin Allmann Updyke: And thank you to you, listeners. We hope that you found this very long episode enjoyable.

Erin Welsh: Yeah and also a shout out to our Patrons.

Erin Allmann Updyke: Yeah!

Erin Welsh: We really, really appreciate you. It's amazing.

Erin Allmann Updyke: We love you so much.

Erin Welsh: Yeah. (laughs) Okay well until next time, wash your hands.

Erin Allmann Updyke: You filthy animals.