Environmental Microbiology with Amy Kirby
Ologies Podcast
April 13, 2022

Oh heeey, it's me. It's your internet dad-uncle back with a highly erotic, not uncomfortable at all episode about… diseases in toilet water. Please don't leave me, please don't go. Don't go… Stay… Please stay. But if this is your first ever *Ologies* episode, there are way less gross ones, let's be real. So, go listen to a less gross one if this is your first ever. Or you know what? Pull up a throne. Because this episode, when you get down to it, is amazing. It's so good.

I nervously showed up early to chat with this government pathogen expert. I heard about this field, Wastewater Surveillance and Environmental Microbiology, a few months back. And on February 4, I tweeted desperately, "I'm just a podcast Twitter account, standing before microbiologists who test sewer water for plagues, hoping they follow me back." And amid much enthusiasm, this guest replied with a GIF that said, "I got you, dude." And here we are. And yes, it's [*soft G*] GIF. It's not [*hard G*] GIF… He said it was [*soft G*] GIF. So, after 1,000 clearances with our nation's Centers for Disease Control, we are off to the races!

Now, this ologist got an undergraduate degree in Microbiology, a PhD in Microbiology from the University of Buffalo, and then also got a Master of Public Health in Epidemiology from Emory University. She is now a Senior Service Fellow at the CDC, and additionally, she has a dog who is a very good dog, and sweet, and sometimes the dog weighs in from time to time in the background. Enjoy.

So, thank you for weighing in, by the way, and spreading the word of *Ologies* like a pathogen, and for supporting at Patreon.com/Ologies for as little as a buck a month. Thank you for rating and reviewing and keeping us up in the charts. I read every single review you've ever left and as proof, here's one; it's still wet, just left yesterday from AeonBlueOphelia, who said that the ADHD episodes were lifesaving. Rachel also left a review saying that they were life changing. Also, SmellsLikeMapelSyrup, a self-described, "Construction worker who randomly laughs at work," go get that ecohydrology career, I hope you like this one too. Y'all, a bunch of you left really sweet reviews this week, I read every single one. Thank you so much.

Also, as a bonus, there's a surprise cameo in this episode from your favorite virologist, about what to do now that mandates and masks are starting to fall, because this episode, boy do we talk about COVID. Also, I cold-called a listener in this and I threw money at them. So, that's in there too.

But onto the show. So, Environmental Microbiology: bacteria, COVID in toilet water, medications in the waterways, plumbing the sewers for medical mysteries, things you can learn from studying stomach bugs, the weirdest things that get flushed, how gross is it for real? Can you get COVID from your stepdad's farts? And what is out there swimming in the world and how can we measure it to our advantage? Including what's on the horizon with COVID. So, if you are getting excited, well, there must be something in the water. So, do enjoy the brain of Environmental Microbiologist Dr. Amy Kirby.

Alie: I like, *so* did not want to mess up anything with this interview that I got here earlier than I have ever been for any interview before. [*both laugh*] I'm so excited. So hi, I'm Alie.

Amy: Hi! I'm Amy, nice to meet you.

Alie: Could I have you say your first and last names and the pronouns that you use?

Amy: Sure. My name is Amy Kirby and I use she/hers pronouns.

Alie: I'm so excited to talk to you. You're doing very important work and I imagine, as we're cresting a little bit of a swell here for BA.2, you're probably pretty busy.

Amy: [*laughs*] We have been busy since 2020. I feel like I tell my team a lot, "We're busy right now but it's going to get better." And then something new happens, a new variant, a new surge, and we are busy again.

Alie: [*sighs*] Oh man. I'm going to ask right out of the gate right now, how are we doing at the moment? BA.2, how are we? How are we doing?

Amy: So, we are doing good. We're seeing overall very low levels in wastewater. So, we've come down out of the Omicron surge and we're back to very low levels in wastewater. However, that said, we are starting to see some communities that are seeing some increases. And so, we're watching those very closely to see if those increases turn into sustained increases and regional increases that would indicate another surge is coming.

In the wastewater system right now, we can't distinguish between BA.1 and BA.2, we just see total Omicron. Which, to be fair, is not very informative at the moment; everything is Omicron. So, that particular data point isn't super useful at the moment. But we will be able to distinguish those sub-lineages soon.

Alie: I mean, I imagine it's just curveball after curveball after curveball.

Amy: It is. And the variant tracking part has been really a challenge because you're always running to keep up with the next variant. There's two different methods that we use for variant tracking in wastewater. One of them is PCR-based; it's very quick and it's very quantitative so we can use it to track changes in variants. It was very helpful to see the Omicron surge because we could see Delta going down and Omicron going up and we got good numbers around that. However, you're always in a race to keep up with the newest variant, right? That PCR only detects that one variant.

Sequencing is a better approach because then we can see evidence of any of the variants of concern and easily adapt to new variants but it's a slower process and isn't as quantitative. So, the measures around how much of a variant is present in a community are not as accurate for that approach.

Aside: Just a quick COVID check-in, where are we at? So, I'm recording this on April 12th, 2022. Yes, that is the same day it's released, that's how we roll. And right now, epidemiologists have their eyes on the Omicron subvariant BA.2. That was first identified in November, but it happens to cause more gastrointestinal issues, so a lot of people right now are mistaking it for a stomach bug. And it's known as the "stealth variant" because it looks like an earlier Delta variant but BA.2 is estimated to make up nearly 94% of cases in the US right now. In the US, cases are up about 10%; but in New York, up about 40%; Philly, I'm sorry, you're up 50% from two weeks ago. And it's probable that rates are higher as people are relying on at-home rapid tests that they don't report, or just no tests at all.

So, what is on the horizon? Perhaps another wave, as masks come off, warm weather gatherings commence, disco make-outs ramp up, it's summer, people get wild. But keep your ears open for another variant called XE. It sounds like a human mix of Grimes and Elon Musk. But XE is really a hybrid of Omicron's BA.1 and BA.2 strains, but with a few fresh mutations.

According to *Time* magazine, early research suggests that XE is around 10% more transmissible than BA.2.

These variants, they come on like software upgrades in the middle of the night that nobody wants. But just check the news and you will find plenty of headlines like, "Latest Wastewater Data Suggests Rising COVID Levels" and "COVID-19 Wastewater Numbers Skyrocket!" And so, of course, *of course*, I had to show up early to talk to the top CDC scientist who is elbow-deep in the data.

Alie: Any cities at the moment that you're seeing a little bit of elevation? New York, I understand. Eastern seaboard? New Jersey?

Amy: Yeah, I wouldn't call out a specific city at this point but certainly we're seeing concerning increases in the Northeast and there we're seeing more and more of our communities starting to see these consistent increases. So, looking similar to what we've seen in the past with surges where a certain region will start to set off the surge and then it will move across the country… Staying on high alert for that.

Alie: Were you always someone who was very up on latest trends? Are you obsessed with TikTok trends? How do you feel in general about keeping up with what's happening?

Amy: I mean, I'm a typical science nerd, right? How trendy can we be? But yeah, I mean, I think it's always fun to stay on the cutting edge of what's coming. I don't necessarily think of wastewater surveillance as being trendy. It's something that we've been thinking about for a long time in various fields, and we've been using it for polio for decades.

So, it was really about seeing the opportunity to apply a technique to a new problem. And we already had the information that we needed and how wastewater surveillance works, we just had to build the right system to use it for COVID at the national scale. That is something I do like to do, is watch for these opportunities and see. Where can we leverage the unique skills we have? So, I'm an Environmental Microbiologist by training, we are not usually part of the public health infrastructure, that's very skewed toward clinical microbiology. So, it was great to be able to hop in early and say, "There is a role for environmental microbiology here. Here's what we can bring to the table."

Aside: What we can bring to the table… is wastewater. Maybe we can bring it to the table but set it down on the ground next to the table.

Alie: I would love to know a little bit about the history of this. You mentioned other diseases. Can you tell me a little bit about where this started and where you started getting really excited about what we can find from wastewater?

Amy: Sure, so the long history of the field is really based on polio surveillance. So, when we started working toward polio eradication in the '60s, one of the challenges there is that the clinical outcome that you're most concerned about for polio is, of course, acute flaccid paralysis. But that is rare; most people that are infected with the polio virus do not go on to have that very acute outcome. In fact, most of them don't have any symptoms at all.

Aside: Just a little history lesson here and a trivia tidbit. So, we didn't have a vaccine for Poliomyelitis virus until the 1950s, and then in the 1960s, polio inoculations arrived, not by needle so much but via a liquid tincture of weakened virus saturating a sugar cube. Hey, what year did *Mary Poppins* come out? Was it 1964? [*A Spoonful of Sugar plays: "A spoonful of sugar helps the medicine go down, the medicine go dowwwn, the medicine go down."*] Yup, that

song was written the day that the songwriter's son got his delicious polio vaccine. [*Mary Poppins says, "Cheeky."*] But yes, scientific sewer spying also aided in the polio fight.

Amy: And so, we knew that if we were looking for only this very severe outcome, we were going to miss… I wasn't involved. But you know, we, collectively, the field recognized that they would miss most of the cases in a community. And as you move toward eradication, that's more and more important because every one of those cases that you miss could be a source for another case.

Polio virus is an enteric virus, it's transmitted through fecal-oral transmission, so shed in stool, you get it on your hands or on your food and then consume it, and that's the transmission mechanism. [*"Eww, but okay!"*] So, they knew that they could look in stool and wastewater to detect the polio virus and they use it to identify neighborhoods where polio is circulating and then they go into those neighborhoods and do a vaccination campaign to protect everybody. So, that's how they've been using it; it works very well to target that intensive polio vaccination where it's most needed. And that was where it stayed, basically until 2020.

Previously to working at CDC I worked on norovirus which causes the stomach flu, basically. And one of the things that we always used to say in the field is like, "Wouldn't it be nice if we could have a community stool sample?" Because so many people get norovirus, they suck it up for a day and feel terrible and they never go to the doctor. So we don't measure those people. And wastewater surveillance was a way to think about doing that. But there wasn't enough benefit; the return on investment to establishing a wastewater surveillance system for norovirus was not high enough to get the infrastructure built. So, we always just kind of hoped for it and never really were able to move on it.

And then when COVID hit and we saw that it behaves very similar to SARS-1, which we knew was shed in stool, we immediately started thinking that we might be able to use wastewater surveillance for this. We engaged with some early collaborators that had systems where they were already testing wastewater, so we could fund them to look specifically for SARS-CoV-2 in wastewater to see if, you know… Can we see early evidence that this will in fact work?

Aside: More on this exact moment of inspiration in a bit and it's good, trust me. But Amy says that they began building the foundational data in early 2020 and by May – around the time you were whisking up Folger's crystals into history's most disappointing treat, a Dalgona coffee… we all fell for it – Amy's team at that time, spring 2020 felt confident in the biology and epidemiology of wastewater testing. So, they move fast, and they needed to establish a system.

Amy: And very quickly we started pulling together… How do we get utilities on board to take the samples? What labs are going to be able to do the testing? What data system are we going to stand up to collect the data at the national level? We spent a few months pulling all of that together and the system was officially launched in September of 2020 and has been growing rapidly since then. [*clip from news report: "Experts say if you want to understand how COVID spreads, check your toilet, and just like what you'll find there, the news isn't all that pretty… Wastewater samples revealing record levels of coronavirus across the US."*] We have over 700 sites reporting into this system and collectively they represent just shy of 100 million people, so we're already covering almost 30% of the US population.

Alie: Wow! And do you have to train people at different sites how to collect samples? Do they ship them to CDC headquarters in Atlanta? How are you gathering all of the sampling?

Amy: Yeah, that has been a huge effort. One key was recognizing that there's already a lot of expertise out there in how to do these things well. So, working with our utility partners, who are absolutely critical for this… if they won't take the samples there's nothing to test. So, working with them and asking them, what are the best ways to take this sample? Where in a treatment process should we be sampling? Are there better ways to do it? What equipment can help us? How can we normalize for how much sewage is flowing through the pipes? And really engaging with them around their expertise.

Talking to the laboratories about testing; we do not have a standard method for testing, measuring SARS-CoV-2 in wastewater. There's a handful of methods that have proven to all work reliably and so we support all of those. And largely it was our academic laboratories where this expertise lies; they were very engaged in developing and really optimizing the methods and are still part of it. Many of our states are using academic laboratories as their surveillance laboratories, right now.

Aside: So, the fieldwork, shall we say, involves utility workers gathering samples at 755 different treatment plants all over the country. The analysis work goes to different labs and then the CDC manages all the data sets and figures out what in crap's name is going on below our feet and in our bodies. But, like a drain, let's back up.

Alie: And can you tell me a little bit about your start in this? When you began your science journey, what kind of questions did you want to ask? And what kind of tinkering, and collecting, and field sampling were you doing?

Amy: So, my history, like many people in public health I think, was not a straight line to this work. So, I always knew that I was really interested in infectious diseases, and the pathogenic process, and how something so tiny can cause such big impacts on people, on society. I wasn't sure in, like, high school and college, what scale I wanted to work. I think looking at things as detailed as gene regulation, which is what my graduate work was on, is fascinating, all the details of how these systems work at a molecular level. But I also think things like infectious disease history are fascinating and how big pandemics, like this, can really shape history.

As I said, my initial training was at the molecular level. So, after I got my PhD in Molecular Microbiology, I got a Master's of Public Health and Epidemiology and continued to work at Emory University for about five years doing public health research; that's where I did the norovirus research. And then in 2017 came to CDC, initially focused on environmental antibiotic resistance, so starting our program to look at environmental AR.

And then when the pandemic started in 2020, we knew there was a need, or an opportunity, for environment microbiology to contribute, even more broadly than wastewater surveillance. Remember, there were a lot of questions about things like surface survival, and disinfection, and all of that when SARS-CoV-2 was new; those are environmental microbiology questions. So, in February of 2020, I was… we say, deployed to the response. So, still reporting to CDC campus, but a different room. [*both laugh*] So, instead of doing my regular work, I was doing response work for COVID. And those early days were focused on disinfection, surface survival, all of the things that went along with that. Response work, for anybody that's interested in public health, it is the thing that we all live for because you get to answer the questions that matter, and you never know what's going to be on your desk.

Aside: What will be on your desk is so many things. But yes, always in the back of her mind was…

Amy: What about wastewater surveillance? Can we generate data for wastewater surveillance? And like I said, by about May of 2020, that had become my full-time job.

Alie: You know shit gets real when they use the word "deployed," by the way.

Amy: [*laughs*] A lot of people get confused by that. It's like, we're in the same building, just a different room.

Alie: Yeah, but a little bit higher stakes almost, it feels like. It feels much more emergent for sure, at least it sounds like it. But what is your day-to-day lab work like? How much are you analyzing data sets? How much are you tinkering with pipettes? Teaching other people how to do it?

Amy: Yeah. So, I think one of the things that people often misunderstand about the way surveillance systems work that are run by CDC, we actually don't do the lab testing. So, it's much more efficient for a large-scale system to set up the testing in each state. So, it's close to where the samples are coming from, right, a distributed method for testing. So, we do a lot of technical assistance for labs, answer questions, and help them get connected to all of the resources that they need, but we're not doing any routine surveillance testing on campus.

What we primarily do here in the laboratory is method development and validation. We're already thinking about, "This is a great system, we've built it for COVID, but we could look for so many other things." I could go back to my old friend norovirus [*"Ohhh, helloooo."*] and now we've put in the investment to build this infrastructure, now it's a much lower bar to also look for norovirus. So, we can get that data in the future. So, we're method development, validation, tinkering, make sure we really, thoroughly understand how those lab methods work so that when we're on the phone with the labs that are doing the work we can be as good as possible in our technical assistance.

Alie: Where do you get your practice wastewater? [*Amy laughs*] You've got to get it from somewhere.

Amy: We have our sources. [*Alie laughs*] So, we're based here in Atlanta, and Atlanta has, like many large cities actually, has multiple wastewater treatment systems. And so, we have long-standing collaborations with our local utilities. We can call them up and say, "Can we get five liters of wastewater on Tuesday?" And they say, "Sure!" And we go get it [*Alie laughs*] and that becomes our sample matrix.

Alie: How treated is it? Be real with me? Where along the assembly line is it?

Amy: So, we collect it, so the way it comes in… And this is actually fascinating. I should say that all of the people that work, certainly in NWSS… [*pronounced "news"*] So, NWSS is our acronym. A good government program has to have a pronounceable acronym. We're the National Wastewater Surveillance System and we pronounce it "news". But all of our NWSS folks, we get a little nerdy about wastewater systems [*laughs*] so we really like to go out and see how they work.

For NWSS testing, the wastewater comes into the plant, there's usually a very large grate that acts as a prescreen, so it filters out all of the really big things. I mean, they get all kinds of things: furniture, Teddy bears, branches, sticks, tires, all the things that flow into sewer mains. So, it's going to get rid of all those big things, but everything else is going to come through. And that is where we take our sample. So, it is completely untreated [*"I've been swimming in raw sewage, I love it."*] when we get it.

People often think that there's whole poops floating around in there, that's not what the sample looks like by the time it gets to us. There's a lot of mixing as all of the pipes come together and so all of the stool will break down. What it really looks like is if you wade up into a river and kick up the mud on the bottom, or there's been a lot of rain and it's just kind of muddy river water. That's what it looks like.

Alie: Yup. That's what I would figure. I feel like it's a lot more translucent than we imagine. How do you make sure that you don't get pink eye all the time?

Amy: So, we have a lot of biosafety restrictions. And frankly, COVID is one of the least concerning things in wastewater, for risk. Yeah, really what we're detecting mostly is decayed viruses, so they're no longer infectious. So, the risk for COVID from wastewater exposure is very low. However, plenty of other things; you can get pink eye, you can get norovirus, you can get *E. coli*.

Aside: This is the CDC, people; they're not doing sewer analysis while eating a hot dog and wearing biz-caj. There are rules.

Amy: There's all kinds of pathogens there. We handle wastewater at a BSL-2+ standard. So, we have to have gloves, eye protection, of course closed-toed shoes, lab coat; so that's a BSL-2. The + is respiratory protection and that's for that low-but-possible exposure to respiratory pathogens like COVID. So, an N95 mask in addition to those things.

Alie: How often are respiratory illnesses enteric? How often are they detectable through wastewater?

Amy: That is an excellent question and I think it's more common than we think. Because we know other respiratory infections like COVID do. So, SARS-1, which luckily did not turn into a pandemic, is shed in stool.

Aside: And just a quick background, severe acute respiratory syndrome, AKA SARS-CoV-1, this was a coronavirus that hopped from animals to humans and in 2003 caused an outbreak with a case fatality rate nearly ten times that of our current SARS-CoV-2. However, SARS-1 infected around 8,000 people in total; it killed 774. So, we learned a lot from that smaller SARS outbreak, but not enough.

Amy: We know that influenza is shed in stool, we know that respiratory syncytial virus, which causes a lot of really terrible infections in children, is also shed in stool. My guess is that is not an uncommon feature of respiratory infections, but we don't have a lot of data on it because the symptom and the transmission method is all respiratory. So, the focus has always been getting those respiratory specimens. Fecal shedding has been thought of as a weird quirk of the infection but not really relevant to the clinical course, so we don't have good data on that. But people are looking at it now; we are getting more and more data on flu, RSV, and some of the other respiratory viruses as well. So, I expect we will learn a lot about that in the coming years.

Aside: So, just think of the last two years of your life, on Zooms, meeting your friends' babies through plate glass windows, as our golden age of pandemia because we're learning so much, so fast. And why I was so thrilled to chat about murky water with secrets to tell is because environment microbiologists, such as Dr. Kirby, can potentially get much more reliable and objective data by overcoming the human hurdles of test availability and self-reporting. But what do they need to accurately predict a disease wave before it comes and crashes on us?

Amy: So, we can't use wastewater data for COVID to estimate cases right now. And that's because we don't have enough information about that shedding parameter to know how much virus is shed by a single infected case. So, what we see is that the trends align quite well but we detect them earlier in wastewater than we see them in clinical cases. Omicron peaks in both cases and wastewater are much higher than what we saw for Delta, so the magnitude parallels what we expect for cases.

And I think one of the things that we have always thought about was surveillance, I know people get tired of hearing about this, but it's the surveillance iceberg, has always been our analogy. [*"Iceberg! Right ahead!"*] What we can detect in surveillance, particularly clinical surveillance where you're waiting for somebody to go to the doctor, get tested, the test has to be correct, and reported; those are a lot of steps. You're only getting the tip of the iceberg for all the cases, because you lose information at each step. And really the biggest one is getting someone to go to the doctor. All of those community cases that we miss because they either don't go to the doctor or they don't even have symptoms.

So, we can estimate back to get what we think the true burden of infection is, but I think wastewater data is really powerful because we can get at that community level without having to estimate anything. It's a way to measure it in the lab. So, what we have to do now is figure out, when we get that wastewater level, what is the best model to go from that wastewater number to a number of cases? And I think we'll get there. We're not there yet, there's still more research to do, but that is really where we want to be able to go.

Alie: Like there is a specific algorithm or equation that can… That is out there, that is undiscovered, as of yet, but can maybe show that "if this is the level that's shed, this is a good number to figure out how many cases there are."

Amy: Right. It's not even undiscovered. So, there's already models out there to do this. The problem… I'm going to give you a little jargon here. The problem is the models are not what we called "fully parameterized." So, the easiest way to think about this is, if we have a certain amount of – let's use SARS-CoV-2 – RNA in wastewater, if we want to know how many cases we have from that, one of the things we need to know is how much virus does each case shed? Right? What's the divisor for that number? And that's the number we're missing. That's a parameter in the model. It's not the only one but it's one of the key ones. And we don't have good data on that right now, we have very limited data.

What that means is that our model is very uncertain, and we get a huge, wide range of possibilities. And right now, those estimates are so wide that they're really not useful. It's equivalent to saying, "Well, the likelihood is somewhere between 1 and 100%." Which is not a very useful thing to say. [*Alie laughs*] So, we need to get those parameters tighter so that our estimates get tighter and more useful.

Alie: And what influences the amount of RNA? Is it RNA from the virus that you're picking up? Is it the severity of the case? Is it how much fiber someone eats?

Amy: It could be all of the above. So, certainly we want to look at symptoms versus no symptoms. Early data suggests that that doesn't make a difference but there's not a lot there, it could change with more data. Now, we need to think about, does vaccination change your shedding? Does it look different if it's a breakthrough vaccinated case versus an unvaccinated case? Does shedding change with variants? Maybe Omicron sheds a lot more than Delta or Alpha. So, we don't have that information. And then the other piece… So, that's the sort of biological piece about the human infections.

Aside: So, part one is your biological pipes and then *number two* is the industrial aspect, so the municipal guts and concrete shoots, this shitshow ballet performed every day underneath our communities… [*quiet admiration*] It's beautiful.

Amy: The other piece is, what's the impact of the wastewater system itself? So, how long is the virus in the system, in the pipes, before it gets to the wastewater treatment plant and we sample it? Because the longer it's in those pipes, the more it's going to decay. So, we have to take that into account. Also, a lot of things come into a wastewater treatment plant, some of them can be very harsh, especially if you have a lot of industrial input. So, there can be really harsh chemicals there that can accelerate that decay. So, we would need to know what else is coming into the system that we would need to be able to account for to correct those numbers, to account for those changes in the system. Those are the two big categories of data that we would need to put into that to accurately make that estimate back to cases.

Aside: So yes, our bodies may react to different variants differently and your guts, yours, may process viral particles in novel ways with a vaccine-fortified immune system. But we are not the only factor. Because remember that while wastewater treatment plants give us a great overhead view, there may be less control over the sampling conditions. Scientists are always solving problems, which really bowls me over.

Alie: How do you feel when you have those kinds of question marks or those puzzle pieces? How do you approach them? Because I'm thinking about being at your desk and being like, [*through sobs*] "We don't know how much bleach is in the water, we don't know…" And I just picture myself sobbing. How do you approach these hurdles, and the curveballs, and the new trends and variants? How does your science brain approach it?

Amy: I mean, CDC, it's all about having the right network and being collaborative with the science community at large. So, we have our networks of academic collaborators that we can reach out to and say, "Hey, have you ever thought about this problem?" How do you measure the time it takes for a flushed toilet to get from a house to the treatment plant? It's called residence time. How do you measure residence time? Can we get good estimates of that? What's the fluctuation? What's the decay? And so, asking them all of these questions and getting their ideas, and do you, Researcher A, have a platform available where you could ask that question? If the answer is yes, then the question for me at CDC becomes, well how can I support them getting the resources they need to answer this critical question? So, that's how we solve it, largely, is by relying on our collaborative network that's available to us.

Alie: Well, I have a basic question here. Does that mean that knowing you have this network and that can help you solve these giant problems, does it make workplace teambuilding and office politics any more challenging, or easier? Knowing, like, you better have friends in the building because you're going to have a lot of questions and you might need help. [*laughs*] Is everyone pretty tight at CDC and just, like, doesn't let grudges stick around?

Amy: I mean, we're human, I will say that. [*Alie laughs*] We are human people working here. But yeah, I mean it is an excellent place to work. I would be lying if I said otherwise. Ultimately, we're a very mission-driven agency and everybody wants to support the science as best they can. So, if I am willing to go to a colleague and able to convince them that doing this is going to be the key to moving some public health issue forward, they're almost always willing to get on board. So, it is a very collaborative agency both internally and externally and that's how we're able to move quickly.

Aside: Let that perfectly diplomatic answer serve as yet another reminder that science is done by human people; ones who have birthdays, and go through breakups, and when they're not trying to fix a pandemic, they buy bathing suits at Target, and they have opinions about cauliflower rice. And in some people's professions though, holding a grudge about a parking space could lead to thousands of people needlessly dying. So, let's get along.

Alie: What about myths that people think about your job or environmental microbiology? Any jokes that you have heard a thousand times? Or any myths that you want to bust?

Amy: Well, I don't know about jokes, but we are a bastion of puns. I have a lot of really funny people on my team so we talk about, "What can your poo do for you?" To try and rally people for wastewater surveillance. "Your number two is our number one." [*Alie laughs*] We've got quite a few. And I have to tell you that the NWSS acronym, when we came up with that, the pun possibilities were a big part of why we went with it. Because immediately we were like, "Oh! When you do your business, we get the NWSS. That's perfect!" [*both laugh*] So, yeah, we do a lot of that.

Aside: I had a hunch; I could just smell it. Speaking of aromas, how does a legit CDC epidemiologist feel about Twitter user @TerriDrawsStuff's November 2020 revelation that "There are angry ladies all over Yankee Candles' site reporting none of the candles they got had any smell at all. I wonder if they're feeling a little hot and nothing has much taste for the last couple days too." This tweet made the rounds, and it led to Stanford Psychophysiology PhD student Kate Petrova to decide, "You know what? Let's look into it." And harvested one-star reviews from scented candle emporiums all over the internet and then crunched those flaming numbers because sometimes the data is right under your nose.

Alie: What about collaborations with the epidemiologists at Yankee Candle? Do you ever have to follow what they're finding?

Amy: I don't, that's a great question. I had forgotten about that whole piece, that they were getting a lot of complaints because no one could smell their candles. We are open to unique collaborations. I don't know that NWSS necessarily has a role with Yankee Candle, but certainly, we're always looking for new ways and novel approaches to get at these questions because they're hard. Like you said earlier, this is something that… there's a lot of challenges, and we don't have all the answers but the way to get to them is to be open to possibilities.

Alie: It's literally life or death. The work that you're doing can lead to huge breakthroughs that can really protect people. We got so many questions from listeners; can I lightning round you?

Amy: Of course.

Aside: Okay so this first question was asked by patron Amy Narimatsu, who wrote in, "I work for an environmental nonprofit and water quality is a huge part of our work. We test for bacteria and other nasty stuff and publish our findings. What's the best way to communicate this data, particularly for the general public who may not understand the language?" So wait, Amy works for an environmental nonprofit. You know what, let's make this episode weird.

Okay, I'm going to call Amy Narimatsu… here we go. She's not expecting my call. I'm nervous about this.

> [*answering machine plays: "Thank you for calling the ShoreRivers, the voice of clean rivers on Maryland's eastern shore. If you know your party's three-digit extension, you may dial it now."*] [*three numbers dialed, phone beeps, then rings twice*]

Amy N: This is Amy.

Alie: Oh hi, Amy, I understand you're the Community Engagement Coordinator?

Amy N: I am, who am I speaking to?

Alie: I'm actually… I'm calling from a podcast…

Amy N: Okay.

Alie: It's from *Ologies.*

Amy N: Oh my— Wait.

Alie: Hiii!

Amy N: I'm sorry is this Alie Ward… Wait, wait, wait, wait, wait. I'm deceased right now. [*Alie howls with laughter*] I'm so shook, I'm so shook.

Alie: [*still laughing*] You're like, "Who's this bitch calling me?" [*laughs*] Number one, I am recording right now, do I have your permission? Is that okay?

Amy N: Sure.

Alie: Okay, it's a very quick call, essentially, I wanted to call because this week's episode, it's with Dr. Amy Kirby who is with the CDC, she's amazing. But because the CDC is a government entity, they can't select a charity so she's like, "I'm going to leave it up to you." And you submitted a question, you mentioned that you're a Community Engagement Coordinator for, essentially, ShoreRivers which helps clean up waterways. So, I was wondering if we can make the donation to y'all instead?

Amy N: That would be amazing!

Alie: Yay! Okay good. Can you tell me in a nutshell what ShoreRivers does? What your mission statement is?

Amy N: Yeah, absolutely. So, ShoreRivers is an environmental nonprofit based on the Eastern shore and we have a mission to protect and restore our Eastern shore waterways through science-based advocacy, restoration, and education.

Alie: Woo! Nailed it, look at that. Engaging the community! Amazing! Sorry that I seemed like such a creep at the beginning. I realized once you answered that I didn't have a plan for what I was going to say to you. [*Amy N. laughs*] I was like, oh fuck.

Amy N: That's the story of my life. [*both laugh*]

Thank you, Amy, for letting me completely interrupt your day with some charitable tomfoolery, and thank you, Dr. Kirby, for having us just roll the dice this week for you. And to learn more about ShoreRivers head to ShoreRivers.org, which will be linked in the show notes. That donation was made possible by sponsors of the show. Thank you, sponsors.

[*Ad Break*]

Okay, no question too crappy, let's see what's coming down the pipe. So, this first one was asked by Specs Owl and…

Alie: Hey Art3mis wants to know: What's the deal with medications down the drain? I know we're not supposed to because it'll get in the water, but I want to know how it permeates, and how much, and all of that? And a bunch of people asked about hormonal birth control in the wastewater...

Aside: Looking right at you Katie Courtright, and first-time asker, Margaret Reese.

Alie: Is that something that you are also having to find ways to measure and come up with some public health guidelines around?

Amy: Yeah, so I am jumping up and down at this question [*Alie laughs*] because yes, please don't put your medications down the drain! Frankly, enough of it comes out in urine and stool on its own, we don't need the added input from the pills themselves going down the drain. Yes, this is something we are interested in doing. There are researchers that are already out there looking at, can we measure pharmaceuticals in wastewater? And what does that tell us about the health of the community? Looking at things like pain medications are one; another option seems like antidepressants. Can we use those as, you know, largescale markers of community health issues that we can provide better interventions for?

Aside: And luckily, scientists are on this and there are reams of studies that you can thumb through such as the 2019 banger, "Pharmaceuticals of Emerging Concern in Aquatic Systems: Chemistry, Occurrence, Effects, and Removal Methods," which I read late at night and this paper whispered facts to me, such as:

> *The presence of pharmaceutical contaminants in groundwaters, surface waters, seawater, wastewater treatment plants, soils, and sludges has been well documented. A range of methods including oxidation, photolysis, UV-degradation, nanofiltration, reverse osmosis, and absorption has been used for their remediation from aqueous systems.*

So, there's a lot of shit in there; they're trying a lot of stuff. And this paper warns that despite our efforts, we are clearly not getting it all. It also told me that pharma-consumption ebbs and flows just like lapping waves of sewer water. And the study went on to cite data that Greece's 2010 economic crisis set off surges in the consumption of psychoactive pharmaceuticals. Also, different parts in the world have higher estrogen water toxicity, while antibiotics are all the rage in other raging waters.

And wastewater filled with antibiotics… Guess what that is? That's just a giant cocktail party for evolution, just a big Petri dish. It's a hometown training grounds for antibiotic-resistant germs that we can't kill. And I just can't help but consider the land that we're on, the mountain streams, and the bays, and the oceans, and the deltas and how their very chemistry has been altered by the remedies that we rely on to survive.

Skimming lists of water contaminants like beta-blockers, anticoagulants, hormones, and pain killers, and antidepressants, and lipid-lowering drugs, and antifungals… You know, I read that and as an American, I couldn't help but wonder… Is it cheaper to get my prescriptions by sitting in a creek? And which rivers have the good stuff?

Alie: Christi Sullivan – I wanted to ask this up-top listener question – wants to know: Who is the person who said, 'Hear me out, I've got a good idea…' and the sentence ended with collecting and analyzing wastewater. Was that you?

Amy: [*laughs*] I actually am going to give the credit to this, and he's going to die when he hears me say this, to our Branch Manager. So, very early on he was like, "Can't we measure this in poo?" [*Alie laughs*] And I was like, "Yeah, I think we can."

Alie: Branch Manager's name? Do you want to give him a shout-out by name?

Amy: Sure, his name is Eric Gross.

Alie: His last name is Gross?!

Amy: [*laughing*] Yes, his last name is Gross.

Alie: Amazing. Is he a doctor?

Amy: He's not, he has an MPH. He actually, sadly, doesn't work on our team anymore. He moved to a different area of CDC. He called himself our resident bean counter because he handled all of the finances.

Alie: Augh, I was going to say, he should get an honorary, just to be Dr. Gross [*Amy laughs*] because a lab coat with Dr. Gross is amazing.

Amy: He'll love it.

Alie: Nina Eve Z had a question I'm sure is on a bunch of people's minds. They say: Oh! I'm super intrigued by this but are there any privacy issues with going through people's poop? Or is it like those fingernail clippings in the waste bin in *Law & Order*? Once it's out of your system and in the system, it belongs to the system, right?

Amy: Yeah so, I mean there is a lot of DNA in wastewater, right? So, the privacy concerns are not unfounded and it's definitely something that we need to address head-on and be very transparent about what we are testing, and what we are not testing, and how that data is going to be used. As far as who actually owns it, once it gets to the treatment plants, it's theirs. And actually, once it's in the pipes that they control to get there, they are officially owners of it and responsible for whatever happens to it. [*"This sack of shit is mine."*] A lot of the information we're gathering is about the community at large, so we want to be very transparent with the community about how we're using this data.

Alie: Yeah, that makes plenty of sense. I also feel like the resources it would take to run a DNA sample on each individual person or each individual fragment, that seems like beyond the capabilities, even of the system, right?

Amy: Yeah, I mean it's not something we're interested in doing. I think about it from what we call a "future use" perspective. What could people do 10 years from now with these samples? 20 years from now? So, we want to put guard rails on that now because down the road that may be something that it's much easier to do but that is an inappropriate use of public health data, it's not what we're gathering it for. So, we want to make sure there's protection around these samples so that they are used only for things that are a community good.

Aside: But she makes an excellent point and raises the *Black Mirror* hypothesis, which is not a real term, it's just something that haunts me when I'm in a scroll hole or I happen upon a jovial news clip about a robotic police dog. Are there any specters in Amy's head?

Alie: Mallory Nettleton wants to know if you've ever seen anything weird or surprising while you're testing? But it is filtered, or at least dechunked by the time it gets to you, correct?

Amy: Yeah, we haven't seen it with wastewater. With other [*laughs*] poop-related studies, absolutely. You learn a lot from people. [*laughs*]

Alie: Really?

Amy: Yeah, you can learn what they eat and their patterns. I often tell my husband, I'm like, "I have spent way too much of my adult life pondering people's bathroom habits for various reasons."

Alie: Anything you can elaborate on? Because I am *curious*!

Amy: The thing that always puzzles me is bathroom patterns. So, I used to do norovirus human challenge studies, that was when I worked at Emory. So, we would bring people into the hospital and intentionally give them norovirus, of course, all fully… They knew what we were doing, all fully consented, they agreed to this, to look at immune reactions, treatment methodologies, those sorts of things.

Aside: Lemme just… I'm going to hop in here and truncate this for us all. So, Dr. Kirby found that some patients were like, "Number two sample? Yeah, I got five of them for you today!" And other people, all of us, the same species, were like, "I just gave you one yesterday, come back in like a week?"

Amy: Just this huge variation in patterns. And in trying to account for that in our data. Like, if you're thinking about daily stool production and daily virus shedding, how do you compare the person that goes three or four times a day to the person that goes once every four days? As long as it's normal for them, we worked around it, but I was surprised at how broad the variation was.

Alie: I think it's interesting that you're surprised at the variation, and I'm surprised that somebody's like, "Yes, norovirus, where's the waiver? I'll sign it." [*laughs*]

Amy: We get *a lot* of that. There are most definitely two types of people in the world: the absolute, "Yes, I'll do it," and the "No way, you could not pay me enough." I haven't met anyone that's like, "Well, maybe."

Alie: Do people get remunerated for their contributions to science in that way?

Amy: They do, yes. Our challenge study subjects did get reimbursed for their time.

Alie: Well, as someone who was lucky enough to dodge some norovirus salsa at a barbecue once… I mean, no one at that barbecue got paid, so there are people out there getting it for no money, just for some free salsa.

Aside: Eugh, long-time listeners know that my inherent revulsion for raw tomatoes saved my actual ass. Now, what about organisms that are not people? Leigh was not the only person with this question.

Alie: Diana Teeter asked: Can you tell from wastewater tests if the pathogen you find has human origin or animal origin? And if not, what further sleuthing needs to be done?

Amy: Sleuthing. We cannot tell… So, when we detect a specific pathogen, we can't tell if it's from humans or animals, assuming it's a pathogen that we know is found in both. If it's strictly a bird pathogen, then we know it's from birds. However, what we can do is we can look for other markers, microbial markers that are only found in one of those sources. So, we use specific microbial markers that are only present in human feces [*"Yum."*] so we can say, "Okay, there's human feces in this wastewater," which we would expect. We can also look for markers associated with specific animals: rats, birds, dogs, cats. And so, we can say what other animals have contributed significantly to this wastewater that may be the source of these pathogens?

Alie: You know, which brings me to a good question. Timothy Hwang and Sydonie Schimler asked: What are the issues with flushing pet poop? And are there ways to monitor animal-based disease versus human disease? Which you just answered, but should people be flushing cat poop? In your opinion, as someone who is an Environmental Microbiologist.

Amy: I mean, they can. It's a safe way to dispose of pet waste in our households, so that's fine. I will stand up for my utility colleagues and say, please don't flush cat litter, it clogs up the system and causes all kinds of problems. But cat poop, dog poop is fine.

I think it's an interesting question of whether we could monitor diseases, animal diseases that way. The challenge there would really be scale. You might predict that, for example, in the city, it's much more likely that pet waste gets flushed than in the country. So, you'd need to account for that difference in your evaluation.

Aside: Also, heads up. Cats can be trained to use a toilet and apparently so can some birds, like parrots, which makes sense, given that they can learn to insult us in our own language. Now, dogs too, have been trained to use toilets and even flush. So imagine, New Yorkers, if you start now, it's April, perhaps you'll have this training thing on lock when winter comes, and you're standing on a frozen sidewalk waiting for poop to drop.

Alie: I thought Ferf Brownoff had a good question. It's a sensitive question, but I'm going to ask it anyway. They said: When I heard about monitoring COVID through wastewater, my immediate fear was, "Can I get COVID from smelling someone's fart?" So, can you get a disease by inhaling particles after someone rips some of that trompet? Do you ever have to worry about something going from enteric to airborne?

Amy: So, for COVID this is not a risk that we are concerned about. Mainly that's because there's no evidence that the virus that is shed in stool or through the GI tract is infectious. In fact, most of our evidence suggests that it is not. So, while we can't totally rule out the possibility, very, very low that any virus coming from the GI tract is going to be infectious. So, a fart wouldn't be any more infectious than a poop.

However, I think this is an interesting question for other infections where we know that a lot of infectious virus is shed. So, we'll go back to my old friend norovirus again. There, we know that infectious virus is shed at very high levels in stool. So, is there a possibility that aerosolized virus from a fart could cause infection?

Aside: Wow, this gets grosser.

Amy: We don't know that, but what we do have really good evidence of is that when people vomit with norovirus, which also happens a lot, it's the winter vomiting disease, that particles… [*little laugh*] This is really gross, I'm sorry to throw this out there at the end. But when people vomit, there's lots of aerosolized particles from that. And there's multiple outbreak studies showing that, really, the only exposure that we can figure out is that that person across the room must have inhaled aerosolized vomit. [*"I don't like this."*] We don't know that it goes through their nose necessarily, more likely they were breathing through their mouth and it's kind of equivalent to consuming it. [*"I think that's the worst thing I've ever heard."*] But certainly, there's very strong evidence that that can happen with a fecal-oral transmitted virus.

Whether or not you would actually aerosolize enough virus through a fart, through your clothes, to be a risk, I don't know. I think it's unlikely, but I wouldn't rule it out. There's a biological pathway there.

Alie: I mean, how lucky are we that we have someone answering these questions for us, somewhere.

Amy: Like I said, I spend way too much time thinking about people's bathroom habits.

Alie: [*laughs*] What is the hardest part about your job? What do you hate the most? You are doing the lord's work! But what's the worst part about analyzing poop?

Amy: I mean well, the worst part, I think, about analyzing poop and anything stool-related in public health is the stigma that people still have around poop and their own poop. So, there's an immediate revulsion, which I understand, it's natural… it's actually protective if you think about the evolutionary reasons for it. But what that means is that people don't want to participate in studies like our norovirus study; they don't want to answer questions about their bathroom habits and how often they poop at work versus pooping at home, which is important for us to understand how wastewater surveillance works and the most effective approaches.

They don't really want to think about scientists somewhere, digging through their wastewater to answer questions. It's just, there's this immediate rejection of it and we have to factor that response into all of our studies. There's a bias that comes with that, of people that just won't participate because it's gross. I'm used to it at this point, but it is hard to overcome.

Alie: Ugh, that is such a good answer and so understandable that that is a giant psychological barrier of other people's, to getting your work done. Imagine if birds were like "Mm, I don't really want you to see my nest, just don't look at my nest, can you not? I don't even nest, I don't even have a nest actually like, never." Like… there's not a lot of shame around so many other fields. That's so interesting. What about the thing that you love the most?

Amy: I mean it's corny, but the thing that I love the most is being able to make a difference. It's the reason I went into public health and got out of molecular micro. I wanted to be able to see that the work that I'm doing has an impact in the community. I loved the work I was doing pre-COVID, but man, as soon as you're deployed to the response, that application of your work takes on a whole different urgency and quickness. You see things go into practice within days instead of weeks, or months, or years.

Alie: Well, thank you for doing it. I'm such a fan of what you do. I just think it's so interesting and it's just the way of the future, I feel like.

Amy: Thank you. Yeah, we think it's going to be absolutely a new paradigm for disease surveillance because it doesn't require any action from people; it's totally passive to the community. So, it's been great to talk to you, and really, thank you for this opportunity.

Aside: Ah! But wait, we have a little more. I'm sneaking in a little insight from Virology guest and repeat guest, Dr. Shannon Bennett of the California Academy of Arts and Sciences, who I got a chance to see a few weeks ago. We chatted in San Francisco, face-to-face, with multiple layers of polypropylene in between, about variants and advice going into our third COVID summer. What are we supposed to do?

> **Alie:** I guess just given what we're talking about, we'll just keep masks on, might as well, we're in a small space.
>
> **Shannon:** Might as well.
>
> **Alie:** We're in a small space. First off, I don't think I had you do this before, but if you could say your first and last name and your pronouns?
>
> **Shannon:** Shannon Bennett, she/her.
>
> **Alie:** Now, we last got to hang out in person, March of 2020.

Shannon: No masks, sitting within six feet, comfortably, in an indoor setting.

Alie: I know, no masks!

Shannon: What a luxury.

Alie: What a luxury it was. If another virus emerges, do you think that this SARS-CoV-2 experience will have us be at all better equipped to handle another outbreak of some kind?

Shannon: Oh yeah.

Alie: That's good! Right?

Shannon: No, this has been an amazing time of building capacity around the world to identify these novel events, and sequence these viruses, and share the data. Just look at how quickly we were able to develop effective vaccines. Honestly, nobody would have ever predicted that we would have been able to have vaccines that, at the beginning, were 95% effective against infection! Nobody tries to even design vaccines to protect against infection, they try to design them to protect against disease. And so, it's amazing that we have this new vaccine technology and it's because, in part, we were able to accelerate the vaccines because of a massive data sharing, massive cross-sector collaboration, massive infusion in production lines for the vaccine. We've learned so much.

Alie: Right, it's kind of forged in fire in some way where, "Well, we didn't necessarily have all of this in place, but we have it now." That's good.

You know, things are starting to open up a little bit. We're here at a science and nightlife event that we have not had in two years, though it will be masked for attendees. Anything that, as we get into summer, it gets warm, people start to act out, they're like, "Let's do it, let's get out. Festivals. I'm ready, I've been bored." Any cautionary advice? Any guidelines?

Shannon: So, I'm fully vaccinated and boosted, and honestly… Wearing a mask, I don't want COVID, but if I did get COVID it would probably be just fine. I'd probably have a pretty mild course; it would be a pain because I'd probably have to control my movements and quarantine. But there are a lot of people that, for whatever reason, they're either not eligible, they can't get the vaccine, they don't have a good immune response to the vaccine. So, right now, I mostly wear my mask to protect others. And I think, as a society, we're still seeing this thing called extra deaths, right?

Alie: That sounds terrible.

Shannon: Yeah I know, it does sound horrible. We understand that a certain, and hopefully a tiny proportion of our population, will always have a very bad outcome to a disease infection event. And with flu, we just… we know what that looks like, and we just have to live with it. People are still dying of COVID, people are still dying of Omicron, and even very young people. So, we need to decide how much of that we can live with. And then I will start thinking more and more about where and when I can take my mask off, relative to the safety of other people.

Alie: Smart. Considerate. I think it's one of those things where no one's ever like, "I really regret wearing a mask to that." But there are times when people are

probably… "Wish I would have worn a mask somewhere." So, you know, better safe than sorry, they say.

Well, I imagine you're going to have a lot of young virologists who are sort of shuffled into this field, motivated by very personal reasons. There's going to be a lot of people probably who have an interest in tackling things before they really become an outbreak.

Shannon: I agree.

So, there you have it. Ask three smart people, dozens of very not smart and truly shameless questions. Thank you for sticking it out. I know that you were like, "Should I listen to this?" You know, you know more now, and you have helped with the hardest part of Dr. Kirby's work, which is people running away screaming from it. And there are links to the studies we cited, there are references, there's a link to the charity for the episode, there's a link of birds on toilets and more up at AlieWard.com/Ologies/EnvironmentalMicrobiology. That is linked in the show notes, you do not have to write it down.

You can follow the CDC; their handle is @CDCgov. You can follow us if you please @Ologies on Twitter and Instagram. I'm on those as @AlieWard. You can head to OlogiesMerch.com to put some *Ologies* things on your body. If you tag it #ologiesmerch on Instagram, we repost you on Mondays.

There are more links at AlieWard.com. Hello to the *Ologies* Podcast Subreddit, hi everyone, and the *Ologies* Podcast Facebook group, which is adminned by Erin Talbert, with help from Shannon and Boni of the podcast, *You Are That*. Thank you to everyone who is a patron, who submits questions, who supports the show, I love you, it's a buck a month to join.

Thank you, Susan Hale and Noel Dilworth, who do so much behind the scenes from scheduling to literally filing our taxes. Emily White of The Wordary heads up our transcripts. Caleb Patton bleeps episodes. Transcripts and bleeped episodes are both available for free at the link in the show notes. Every few weeks we release a *Smologies* episode that has been de-filthed for kids' ears and condensed. Zeke Rodrigues Thomas of Mindjam Media works on those and Steven Ray Morris helps out too. Kelly R. Dwyer updates the website. She can make you a website if you like; her link is in the show notes.

And giant thanks to the man, the mullet, the mustache, Jarrett Sleeper, who if you find him on Instagram @Jarrett_Sleeper, you can weigh in on his recent headshots. Tell him which one is the most astonishing, it's difficult to choose. Nick Thorburn made the theme music.

And if you listen to the end of the episode, I burden you with a secret, if you will. And you know what's weird? I've been doing this show for like, 250 episodes or something… I should know exactly the number and I should celebrate that. And I still get nervous when I record asides. I don't know why. I can edit them if I mess up, I can edit them, it's fine. What do you care? Get into it, you know? And I'm still like… Oh, what if I mess up? You know what it is? I still like this job. I've been doing it since 2017; I still like it. Okay, see you next week, sorry this one was so gross. Love you. Berbye.

Transcribed by Aveline Malek at TheWordary.com

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More on NWSS

Covid in Wastewater: current levels

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Original Yankee Candle Hypothesis

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And here's a potty dog for you