Environmental Contaminants: Pharmaceuticals

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SPEAKERS

Lindsey Reisinger, AJ Reisinger, Ricky Telg, Phillip Stokes

P **Phillip Stokes** 00:01

Welcome to Science by the Slice. My name is Phillip Stokes, one of the hosts of the show. And right now I'm in my car, and I'm turning into the Leveda Brown Environmental Park, which is the waste management facility for Alachua County, Florida. And I'm driving here for a reason that will become apparent in just a few moments. You see, in this series of Science by the Slice, we're focusing on environmental contaminants, what they are, how they end up in the environment, and how they can impact life here on Earth. And right now, in my car, I have an old microwave that doesn't work anymore, I have a pretty good sized bag of used batteries, I have some cans of old enamel spray coating, and also I have a pretty good sized box of expired or used pharmaceuticals or medications. And so I'm taking them to the hazardous waste facility, and I'm going to drop them off so they can dispose of them properly. And then I'm also going to hopefully talk to the employees here and get a little input from them as well. So I'll take you along as I'm turning in now and see what I can find out.

R **Ricky Telg** 01:23

This is Science by the Slice, a podcast from the University of Florida's Institute of Food and Agricultural Sciences Center for Public Issues Education. In this podcast, experts discuss the science of issues affecting our daily lives, reveal the motivations behind the decisions people make, and ultimately provide insight to solutions for our lives.

P **Phillip Stokes** 01:53

Welcome back. Once again, this is Phillip Stokes. So I dropped off those items and everything was very quick and smooth. Unfortunately, the person who could have spoken to me was off this week. The good news is that when items are brought to the hazardous waste collection center, the vast majority is recycled and the waste that cannot be recycled is either neutralized or properly disposed of. And all those materials do not end up in a landfill or another place

where they can leach into our water. And all this brings us to today's episode, where I'm joined by two University of Florida researchers â€“ Dr. Lindsey Reisinger, a freshwater community ecologist, and Dr. AJ Reisinger, an urban ecologist and biogeochemist. AJ focuses on how what people do in the landscape affects what flows downstream and into bodies of water. Lindsey's work is centered around freshwater ecology, including animal behavior and disease ecology. I spoke with AJ and Lindsey about one of their studies that examined how pharmaceuticals can alter ecosystem functioning. You see, pharmaceuticals end up in water bodies when they are improperly disposed of, or when taken by humans, some of the chemicals are absorbed by the body, many pass through the digestive system and are excreted out. So in today's conversation, we discuss how a common antidepressant affects crayfish, as well as other effects it has on waterways and the ecosystem. And the results were quite bold. Stay tuned. Well, Dr. Lindsey Reisinger and Dr. AJ Reisinger, thanks so much for being on Science by the Slice. I just want to give you both a chance to introduce yourselves and tell us a little bit about your position and who you are.

A AJ Reisinger 03:49

Yeah. Thanks, Phillip. Thanks for having us. I'm AJ Reisinger. I'm an assistant professor and the Soil and Water Sciences Department, and I'm also a State Extension Specialist. I focus on urban water quality and urban soil quality, and I kind of think about my job as figuring out how the things we do on the land affect what flows downstream and how we can kind of reduce our impacts on our water bodies and improve their water quality.

L Lindsey Reisinger 04:16

And I'm Lindsey Reisinger. I'm an assistant professor in fisheries and aquatic sciences. And a lot of my work focuses on freshwater ecology, particularly I do a lot of work with invasive species, animal behavior, and disease ecology, and I think about how those things kind of scale up to affect the freshwater community and ecosystem.

P Phillip Stokes 04:39

That's wonderful. Yeah, thank you so much for both introducing yourselves. What we're talking about today is water quality, and just how contaminants and things end up in our streams and in our soil, and how that affects the ecosystem and all of the species that, of course, live in the environment. So AJ, I want to start with you and just ask, what is an environmental contaminant of concern? So what is that, if you could just explain that?

A AJ Reisinger 05:06

Yeah, so I think the specific definition will will vary depending on who and what you're talking about. But if you just look at the word or the title, "environmental contaminants of concern." So, "environmental" â€“ it has to be something that we find in the environment. "Contaminant"Â â€“ it has to be something that isn't supposed to be there, but is found there, that's what a contaminant is, it gets there somehow. And then "of concern," there has to be a reason why we're concerned. So it has to be having or at least the potential to have some type

of a negative consequence on the environment. So if we put those all together, an "environmental contaminant of concern," is some chemical or other pollutant that gets into the environment that is causing some potential detrimental effect.

P Phillip Stokes 05:51

So what are some of the major things that you know we need to be concerned about?

A AJ Reisinger 05:56

Yeah, so there's some classic contaminants or classic pollutants that we think about a lot. And these are things like nutrientsÂ â€“ nitrogen and phosphorus are really well known pollutants [or] contaminants of concern. They lead to things like eutrophication, potentially fueling algal blooms and that sort of thing. But then there are also pollutants that might seem a little more in the classic pollutant sense of industrial compounds that make their way into the environment like heavy metals, or pesticides, or pharmaceuticals and personal care products, or motor oils â€“ anything really could be a contaminant, but those are some of the main compounds that I think about a lot.

P Phillip Stokes 06:41

So like if you walk on campus here at the University of Florida, and you go by any stormwater drain, of course, like what do you see? You see trash, you see pollution, you know, we see a lot of the plastics and things that can build up. But how do some of these other synthetic chemicals, the things we can't see how do those a lot of times end up in our soil or bodies of water?

A AJ Reisinger 07:01

Yeah, so we use a bunch of different chemicals every day in our day to day lives. And some we are aware of, some we aren't aware of, but there's a lot of different things that we use just to go about our days. And there's a lot of different ways that those compounds can make their way into the environment. If you think about just when you flush your toilet, whatever you flush down your toilet is going to make its way into the wastewater treatment process. And if you are on a sewer, it'll go to a wastewater treatment plant. And that treatment plant can remove some things, but it's not designed to remove everything. And so some of what you flushed down your toilet can make its way into the natural environment because it's either discharged directly into a stream or a river or a lake, or it can be transported as a solid waste and then applied somewhere else. But you can also think about what you're using outdoors outside of your house, if you are driving to work every day and your car has a little bit of a gas leak or an oil leak or something like that, then you will be dripping that onto the ground. And sure it's just on the street, not a big deal. But then whenever it rains, whatever that rainwater interacts with on the land will get transported into our stormwater system. So anything that could be spilled or even used intentionally but not intentionally moved on the on the landscape also has a potential to make its way into the environment. We also have things like degrading infrastructure. So our sewer lines are supposed to be perfect and move whatever we flushed

down the toilet or whatever goes down our sink all the way to the wastewater treatment plant. But we know that pipes leak and we know that our infrastructure is pretty old. And there's a lot of known and unknown leaks out there in the environment, and so those leaks can allow that wastewater to discharge directly into groundwater, which then can affect surface waters and soils as well.

P **Phillip Stokes** 08:54

Yeah, so I mean, it sounds like it's a whole suite of things. Some are small, and just, they accumulate over time. But, maybe there's that word there, they "accumulate," right? There might be a small amount, but they do add up and Lindsey, they end up in, like AJ was saying, in bodies of water. Sometimes they just are stormwater drains [that] go right into lakes or streams or creeks. And of course, that's going to affect the environment and the quality of the water and the ecosystem functioning of those animals there. So if you could just tell us a little bit about some of the freshwater systems that you study and how some of these extra nutrients or environmental contaminants of concern can affect the ecology of the the system, if you will.

L **Lindsey Reisinger** 09:40

Sure, yeah, so I've studied all kinds of different freshwater ecosystems. Anything from wetlands to streams to lakes, and a lot of what I focus on are freshwater invertebrates. So these would be things like insects and snails and crayfish that live on the bottom of the freshwater ecosystem. And largely I focus on crayfish, which are very abundant. And one of the reasons we're really interested in the impacts of these kind of contaminants is that they're really, they're designed a lot of times, especially pharmaceuticals, to have an impact in our bodies, and so they're really likely to affect the behavior of organisms. And we know that the behavior of organisms influences things like their interactions with other organisms. So, how vulnerable they are to predators, or, you know, their feeding rate on their prey or their interactions with other species. And so we think that could have a really big impact on the environment.

P **Phillip Stokes** 10:42

Yeah, and you mentioned pharmaceuticals, and I know that's one of the main things we're going to talk about today. And you also mentioned crayfish, so, you know, thinking about pharmaceuticals and the ways that crayfish â€“ the things they consume and the waste they produce â€“ I mean, why are crayfish, why are they an interesting species to study and to use in these some of these experiments?

11:09

Yeah, so I think they're, they're really interesting to study because they tend to just have a really high biomass. So they're just large in general, and so you can end up with systems where they're making up a lot of the biomass of the invertebrates in the system. And although you probably don't go around and see a bunch of crayfish all the time, what they're doing is during the day they're hiding in burrows or under leaves or under rocks. And they come out and are active at night. So although you you might not notice them being there, there can be really a

lot in freshwater ecosystems. And we have them in all the different types of freshwater ecosystems in Florida. And so, crayfish are a really key link between the bottom of the food webs, so things that eat things like dead leaves and plants and other aquatic invertebrates like freshwater insects. And then they're eaten by things like fish, or sometimes waiting birds, or mammals like raccoons. And so they're a really important link between the bottom of the food web and higher order predators, so they can have big impacts in freshwater ecosystems.

P Phillip Stokes 12:22

Yeah, you're right, you don't see a lot of crayfish, even if, like you said, they're there, you know, I know like as a kid and stuff you like, you don't mind getting as dirty and you lift up the rocks. And you you know, you get in the creaks or, you know, wherever, and then you happen to see them. But just kind of moving along. Both of you are authors on a paper, where you looked at a common antidepressant, and it seems like you did a really interesting study design to test out the impacts of this common pharmaceutical on crayfish. If you could just introduce this, and I don't know if AJ or Lindsey, I know you're both on that, so either one of you, if you want to start out.

L Lindsey Reisinger 13:05

Yeah, so we were interested in doing this study, because we know that crayfish have large impacts in the ecosystem, and that they also can be really common, some species can be really common in impaired waters. So it's likely that there's a lot of situations in the environment where there are crayfish that are exposed to pharmaceuticals. And we wanted to know whether a common antidepressant that's been found in our waterways, Citalopram, could impact crayfish behavior, and also whether that would sort of change the impacts of crayfish on the ecosystem.

P Phillip Stokes 13:47

Yeah, and we chose Citalopram and this combination of the antidepressant and the crayfish for a couple of different reasons. But I think one of the primary reasons in addition to the importance of crayfish in the environment, is that crayfish have been used as model organisms for neurobiology and neurochemistry studies to actually look at how different chemicals behave in the brain and how that might relate to human behavior change. So there's been work that's been done on crayfish in the past that's shown that if you inject them with serotonin, for example, it makes them more aggressive. Obviously, in the real world, the crayfish isn't going to get injected with serotonin, but a crayfish might be exposed to an antidepressant that is specifically designed to manipulate serotonin levels in your brain. And so the pharmaceutical that we selected, Citalopram, is a selective serotonin reuptake inhibitor. That sounds complicated, but basically what it means is it blocks different serotonin pathways that changes your brain chemistry and your dopamine responses for lack of a more complicated description. And so this known response in crayfish with serotonin manipulations, plus their potential environmental impacts is why we thought it was a really interesting combination to look at how these behavioral changes might scale up on the broader ecosystem. Yeah, absolutely. So how did you set it up? What was a little bit of the study design and how you went about looking at that?

A AJ Reisinger 15:19

Yeah, so we were working in at the Cary Institute of Ecosystem Studies, before we came to the University of Florida. I was a postdoc there and that's where we ran this experiment. At the Cary Institute, they have an artificial stream facility, which is basically some bathtub-like things that are set up in a race track design, like an oval race track, and there's a paddle wheel that moves water one way in those experimental streams. And so we have this really simplified design of a stream, but we can control everything that goes into that water, we can add different organisms, we can add different rocks, or different chemicals, that sort of thing. So we set up those streams to have different amounts of rocks and leaves and algae. And in some of the streams, we added crayfish. And in some of the streams, we added the pharmaceutical, the antidepressant. In some streams, we added both, and in some streams, we added none. And we let that experiment go for about two weeks. And over the course of those two weeks, we are measuring different ecosystem responses, looking at things like photosynthesis, and respiration, and nutrient cycling. And we didn't see huge effects on those measurements, likely because it takes a while for the crayfish to have an effect. But what we did see were pretty cool and interesting responses of the crayfish themselves.

L Lindsey Reisinger 16:49

Yeah, and at the end of the experiment, we took the crayfish out and we tested their behavior in a different, kind of more simplified setup. And we looked at their boldness, or how quickly they came out of a shelter into a novel environment. And then we also piped in water that smelled like a food source or smelled like another crayfish. And we looked at how much time the crayfish spent going after those to different resources or different things they might be interested in.

P Phillip Stokes 17:23

And I gotta say, I always like it, when you look at studies involving animals and you have to characterize you have to use a human qualities to characterize animal behavior and traits. So I was like, you know, boldness or choosiness or whatever, like we might say, so anyway, so what did you find about the crayfish boldness or what what choices they made?

L Lindsey Reisinger 17:45

Yeah, so their behavior was really different if they had been in one of the streams where they were exposed to the antidepressant. So if they had been exposed, they came out of the shelter almost twice as fast as the crayfish that were not exposed. And they also, if they were exposed, they spent much more of their time, about three times more time, going after the food smell than going after the other crayfish smell. And then the crayfish that had not been exposed spent about an equal time going after both smells. So it did appear to change their behavior, which was really interesting.

P Phillip Stokes 18:25

Phillip Stokes 18:25

So I got to ask about about normal crayfish behavior. So do are crayfish, are they aggressive towards one another? Or?

Lindsey Reisinger 18:33

Yeah, they're aggressive towards one another. And some earlier studies had found if you inject pharmaceuticals, like this one into crayfish, it makes them more aggressive. And so that's part of the reason why we included the other crayfish in the trial. But we really found a different effect where they were not very interested in the other crayfish if they had been exposed and they wanted to go after the food resource.

Phillip Stokes 18:58

So what does that mean for the crayfish that might be going after food more than they normally would if they weren't exposed to that chemical?

Lindsey Reisinger 19:07

Yeah, so it could mean, I mean, so one of the things we think is interesting is coming out of the shelter more rapidly might mean that they would be more vulnerable to predators, because crayfish outside of shelter tend to be really vulnerable. And then if it alters their actual feeding rate, it could affect communities. So like, if they're eating a lot more invertebrates, or a lot more algae or a lot more plants it could affect the freshwater ecosystem. We would want to probably explicitly test those things in a future study though.

AJ Reisinger 19:41

Yeah, we did. So building on that we did find, so we did this whole design. We were very interested in the crayfish behavior, but we're also then interested in okay, how does that affect the other things that are happening in the environment? How does that affect the algal growth or nitrogen cycle or photosynthesis? That sort of thing. And we did find that crayfish on their own did have some significant effects on some of those processes. So crayfish led to more algae in the water. So there was just more algae floating around in the water column of the streams. But it didn't matter if the crayfish had been affected by the antidepressant or not. So it seemed like that was just a crayfish effect. And we think that if the study had been run for longer, it might have allowed for more of those behavioral changes to proliferate in the broader ecosystem. And we might have started to see, like, crayfish that also had the antidepressant might have an even bigger effect than crayfish with no antidepressant, or vice versa. So we saw that with algae in the water column. We saw it with just total organic matterâ€“which is kind of a metric, or a surrogate for biomass of the microbial communityâ€“at the stream bed and in the water column. And we saw it with a reduction in nutrient nitrogen uptake of the spider stream in crayfish streams. So the crayfish-pharmaceutical interactions, or the effects of the pharmaceutical on the crayfish, then affecting the ecosystem was unclear. But I think that there definitely is some potential there and it is definitely worth looking into further.

L Lindsey Reisinger 21:25

Yeah, and some of our other collaborative research together is focusing just on how differences in crayfish behavior within the same species kind of can scale up to affect the ecosystem. And some of our early results do suggest that changes in behavior can affect the ecosystem if we look over longer timescales than two weeks. So we think there's a potential that that effect is there, but we didn't pick it up.

P Phillip Stokes 21:51

So, did you say you ran the study for, was it 14 days? Was that, or?

A AJ Reisinger 21:56

Mm-hmm.

P Phillip Stokes 21:57

14 days. Did you find a difference in some of these, some of the ecosystem functioning over time, like did things change as the study went on? And like you said, like, if you had been running it longer, like, you might anticipate more of that? I don't know.

L Lindsey Reisinger 22:14

Yeah, well, I mean, over time, things happen, like, you know, crayfish are consuming things and excreting nutrients. And so we do see changes in the ecosystem over time, we typically now run our experiments like that over twice as long as that. So we usually run them for about a month, because it does take a while for, especially for the effects of the organism, to kind of affect the whole ecosystem.

A AJ Reisinger 22:43

And for this specific study, a lot of the things that we measured, like the behavior, the ecosystem responses, most of those things are pretty labor intensive to do. And so you can't really do them everyday during the study. We do have one process that we measure, it's called stream metabolism, that we can put sensors in and then use sensors to do some estimation. And we kind of started to see those responses separate out by the end of the study, but it also could have just been random noise, it was definitely not a significant statistical effect. But it's difficult to say how much a lot of these things were changing over time, because it's just hard to measure these things on a regular basis. It's a lot of work to run these experiments. Don't get me wrong.

P Phillip Stokes 23:30

Yeah, I know sometimes on the outside looking in, you think you can just like put like an instrument in the water? And it like does everythingâ€“we have iPhones now. Right? And you know, like, can't one thing just measure everything? I don't know. [Laughs]. Like, sure, but that's a really good point. So, thinking about just the impact of ecosystem functioning a little bit more, and even thinking beyond crayfish, right, there are other, there have got to be other invertebrates taking in these synthetic chemicals and other pollutants? How could you see this example in this study, what can you, what correlations and what other broader impacts on a stream, on a river, on other soils? You know, what could this look like? The more we have things accumulate in the environment, what could this mean over time?

A AJ Reisinger 24:18

For a long time, we viewed pharmaceuticals and other organic contaminants as not significant threats to the environment because they're typically found at really low concentrations. And it's only in the last decade or two that we've actually had instruments sensitive enough to be able to detect these compounds. That doesn't mean they haven't been there for longer it just means that we haven't been able to measure them. And so when we run a typical toxicology study that's often designed to be a study where you add enough of the chemicals to get to the point where you're killing something, where you're killing a fish or killing an algae or killing a bug, something like that. And then you use that to say what concentration is a threshold for the environment. It takes a way higher concentration of these compounds to kill anything than what you ever see in the environment. And so because of that difference, they're often viewed as not an environmental concern. This study though, and other studies like this, it shows that at low concentrations that are commonly found in the environment, these compounds might not kill anything, but they do change how they behave, they do change how they interact. So our study shows changes in crayfish behavior. There are other studies that have shown changes in fish movement and fish predation. Other studies have shown changes in algal photosynthesis, and growth efficiency, and bug reproduction ratesâ€“all kinds of different things have been shown in these individual laboratory based studies. And so we know that at these low concentrations, these compounds affect a wide range of different things in the environment. But it's really hard to then go from this one study in a controlled artificial stream to then say, Okay, this one chemical is one of 10,000 that this ecosystem is receiving every day. And so how all those things interact and affect each other, beats me, beats any of us, we need a lot more research to figure out how these, how these compounds interact. It's clear that they can have potential impacts and they can change the microbial community, which can change the nutrient cycling, which can change the eutrophication, like, all these wide ranging implications. And chemicals can accumulate in bodies, like we know that pharmaceuticals can be incorporated into bug biomass. And those bugs are then fed upon by fish, and then birds eat the fish. And then it changes how the birds fly. And then the birds go and migrate across continents, and so there's really broad scale applications. I'm not trying to overstate how important this is. But I think it's just like, the potential is there. And we don't really know nearly enough about their role in the environment.

P Phillip Stokes 27:02

Yeah, it's almost like the industrial era of, you know, people, right. And it's been relatively short, right. So it's, what, the anthropogenic effects, we're just kind of starting to see some of these things. And that is a really interesting question of how all of these interactions come

together. What other things need to be looked at? What are the other questions that keep y'all going and make you excited to look into these things more?

L Lindsey Reisinger 27:34

Well, yeah, well, I would say, I mean, I think one complicated thing, right, is that, and I think AJ touched on this a little bit, is that, you know, these compounds are not going to occur by themselves in the environment, like, you're not going to have a stream where you end up just having this one antidepressant. Like, the fact that the antidepressant is there means that there's probably a whole bunch of other suite of other things. So understanding more about the common chemicals that you'd have together, and how those impact organisms is, I think, a key direction for the future.

A AJ Reisinger 28:11

And I think also, so, I'm trained as somebody that looks at how nutrients and contaminants cycled through the environment. And I, for a long part of my career have looked at the animals or the plants in there as just like, oh, there's a fish, it doesn't reallyâ€“it's some ambiguous fishâ€“it's going to do the same thing as every single other fish, from the broader perspective. Obviously, that's not right, and an oversimplification, and we know that, but a lot of our work is showing how variable, even individual organisms, like, it's the same species of crayfish or the same species of bug, but from one to another, they can be really variable. And that variation can really have a lot of different impacts on how we think about these organisms and their interactions in the environment, but also what they really do, and how we can manage them, and how we can protect and preserve them, or like, try to manage them if they're a problem. I think that delving down further into the individual response to some of these compounds is really important. And something that often gets overlooked.

P Phillip Stokes 29:17

Yeah, so if anyone's listening, and they're thinking, you know, it's always nice to have a call to action, right? Or, you know, people want to be empowered to help the scenario, whatever that is. And yeah, so what are what are some things that you would just say, when we're thinking about water quality and the species that live there, what are some things that you would tell the listeners about, things that they can do or advocate for, personal actions, whatever?

A AJ Reisinger 29:45

I think the easiest thing to do or the easiest thing for an individual to do is to manage what chemicals you use and discharge or get rid of or what have you, however, you want to say that. Anything you flushed down the drain, put down the sink, use in the shower, flush down your toiletâ€“anything like thatâ€“that's all going to have the potential to make its way into a stream or a river. It might degrade at some point, it might be treated, but it might not. And it might be innocuous, or it might not. So limiting the chemicals that we use on a daily basisâ€“I'm not telling anyone to stop taking their prescriptions from their doctor, like, medication is great. It makes us healthy, happy, live longer lives, etc. But use the prescriptions

and the medication that you need and dispose of them correctly. So if you're done with medication, and you don't want to take it anymore, you don't need to take it anymore. Don't put it down the drain. There are proper ways of disposing of unwanted medication that includes things like bringing them back to a pharmacy or a police station, a sheriff's office, they often will take back unwanted medications. We actually have an Extension factsheet about disposing of unwanted medications if you want more information. So that's probably the main thing that an individual can do that would haveâ€“it might not have a huge impact for one individual to do, but if we all do it right, that can start to add up.

L Lindsey Reisinger 31:12

Yeah, and maybe this is slightly off topic. But I would also say that you know, knowing that organisms are different and inhabit, you know, sometimes we have crayfish or fish that really only inhabit one drainage in Florida or a couple drainages, so being careful about moving organisms, live organisms between drainages. So, like, if you're using crayfish as fishing bait, not releasing those crayfish into the water unless you got them from that same stream would be a really helpful thing to do as an individual.

P Phillip Stokes 31:47

So if people want to learn more about your research and your labs, how can they find you? And we can also include that in the show notes.

L Lindsey Reisinger 31:54

Yeah, so my lab web page is reisingerlab.weebly.com. So you can find information about my research there.

A AJ Reisinger 32:05

And my lab web page is ajreisingerlab.com. My Twitter handle is @AJReisinger â€“ R E I S I N G E R. I am quite active on Twitter, probably more active than my wife would like. And so you can find me there, and you can also, if you have any questions or comments or ideas, feel free to send me an email or give me a call. As an Extension Specialist, my duty is to help people throughout the state of Florida and broader on how to reduce their impact. So I'm happy to chat with anybody that's interested.

P Phillip Stokes 32:42

Well, great. Well, Dr. Lindsey Reisinger and Dr. AJ Reisinger, thank you so much for being on Science by the Slice. It was a pleasure talking with both of you.

R Ricky Telg 32:55

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