## Phosphorus and Algal Blooms (Part ¼)

## Season 1, Episode 15

**[Music]**

**John McMaine:** Hello everybody and thanks for joining us again on Streamlines, your source for water knowledge. I’m your host John McMaine…

**Anthony Bly:** And I’m Anthony Bly.

**John McMaine:** And this, Anthony, is episode 15!

[transition music plays]

**John McMaine:** And today we’re going to talk about phosphorus with Lindsey Pease. So, I’m just going to let Lindsey introduce herself, and then let her kind of share an experience she had with phosphorus and algae. And this is going to shape our discussion over the next 4 episodes.

**Anthony Bly:** Wow! 4 Episodes on phosphorus.

**John McMaine:** Yes, it’s a big topic Anthony.

[Anthony laughs]

**John McMaine:** So, Lindsey Pease.

**Lindsey Pease:** My name is Lindsey Pease, and I am an assistant professor and extension specialist in nutrient and water management at the research and outreach center for the university of Minnesota. I started studying phosphorus when I was working towards my PhD and I was working with USDA ARS there, and Norm Fausey, and he had a lot of drainage sites that were in the western Lake Erie basin, and at that time we were both looking at Nitrogen and Phosphorus in the drainage system. It was actually 2014 and I was working on my dissertation when the Toledo water crisis happened. I grew up in western Lake Erie basin, I grew up in a suburb of Toledo and my parents still lived there and they actually got a phone call at 5:00am, telling them that their water isn’t safe. It’s a wild story and I think really people take it for granted their water is going to come out of the tap and it’s going to be safe, and then you get that literal wake-up call, it was pretty shocking. Then, phosphorus really entered the public eye, I guess you could say, as a potential water quality problem.

**John McMaine:** So, Toledo Water Crisis, you’re familiar with that?

**Anthony Bly:** Oh yeah. I heard about that yeah. I didn’t know Toledo had suburbs. I just can’t believe that, but I guess so.

**John McMaine:** Yeah, yeah. I mean Brookings, right? Brookings’s suburbs are Volga and Aurora. No one other than people from South Dakota will get that joke, but…

**Anthony Bly:** Yeah…

**John McMaine:** Anyways, yeah, the Toledo Water Crisis; three days without drinking water and really uncertain about what the future held as far as when they would get water.

**Anthony Bly:** Right, right.

**John McMaine:** That’s a big deal.

**Anthony Bly:** Yeah, and how dangerous is it? You know and you start thinking about that.

**John McMaine:** Right, and so, that’s really what we’re going to jump off of why phosphorus is drinking water and water quality issue. It’s not because of the phosphorus itself, but it’s because phosphorus is the limiting nutrient for algae. Typically, in freshwater systems and so, once phosphorus gets into the system then that algae has everything it needs. Once it gets to phosphorus it can take off.

**Anthony Bly:** Yep. It’s an instigator.

**John McMaine:** It’s a catalyst and not a good catalyst. So, indirectly…

**Anthony Bly:** Oh, the algae think it’s good.

**John McMaine:** This is true. The algae are having a great time. So, the other reason we think about phosphorus is because it’s one of the 3 macronutrients.

**Anthony Bly:** Plant essential nutrients, yep.

**John McMaine:** Yep, critical for life. Critical for human life, plant life, algal life.

**Anthony Bly:** ATP. Adenosine triphosphate.

**John McMaine:** Yeah, man that’s like… I remember that from biology.

**Anthony Bly:** Oh yeah, botany.

**John McMaine:** That’s probably the last time I saw that was in high school.

**Anthony Bly:** The Krebs Cycle.

**John McMaine:** Oh man! Digging back to my…

**Anthony Bly:** I’m an agronomist!

**John McMaine:** This is true, yeah. So, and then a local example. Here is lake Mitchell and we’ll talk

about Lake Mitchell later in the episode whenever we talk about concentrations, but I guess just to bring home that it’s not just a lake Eerie issue...

**Anthony Bly:** Right. It’s an everybody issue.

**John McMaine:** It’s an everybody issue. Almost any freshwater system in the U.S…. well, I don’t know maybe that’s a broad system. But a lot freshwater systems in the U.S. from farm ponds to Lake Eerie, you know, the Great Lakes…

**Anthony Bly:** Correct. I noticed the Big Sioux had algae in it.

**John McMaine:** Sure enough, yeah.

**Anthony Bly:** Yeah.

**John McMaine:** So, we’re in a drought right now, and so there’s less volume. The phosphorus doesn’t go away, so as your volume decreases that phosphorus can concentrate and…

**Anthony Bly:** Yeah, you get algae bloom, yep.

**John McMaine:** Yep.

**Anthony Bly:** It might not be the wrong algae, right? I mean there’s different kinds.

**John McMaine:** Yeah, and so there is a differentiation between, I guess, nuisance algae and then cyanotoxins.

**Anthony Bly:** Right.

**John McMaine:** So, then the algae that actually produces the toxins.

**Anthony Bly:** Yeah. We don’t want to lead anybody to believe that there’s a big problem there.

**John McMaine:** Yeah.

**Anthony Bly:** But I just was commenting.

**John McMaine:** Yeah, just the presence of algae does not indicate harmful algal blooms. And really, although it’s challenging because you have to look at it under a microscope, or you know, do some actual lab test to determine if it’s… and actually, usually it’s whether it’s producing toxins or not, is how you determine if it’s a harmful algal bloom. Yep.

**Anthony Bly:** Wow.

**John McMaine:** But anyway, let’s go back to Lindsey, hear the full story of the Toledo Water Crisis and then we’ll dig into phosphorus and tile drainage, and then kind of some of the nuance there related to surface runoff and subsurface drainage. And then from there, we’ll go onto kind of why phosphorus is such a challenging issue. So, Toledo Water Crisis from Dr. Lindsey Pease.

**Lindsey Pease:** Something that’s really interesting about what happened is that I think, prior to the water issues that we saw in Western Lake Erie basin was another lake in northwest Ohio that had phosphorous problems and that was called Grand Lake Saint Mary’s and that one had such a bad algal bloom that dogs were getting sick. I think that someone’s dog actually died due to the toxic levels, and that was a bit of a different situation because that was all within one county. It was the most animal production that was happening really in that part of the state. And it was a man-made lake, so it had all these problems; it didn’t have any natural outlet for the phosphorous to leave and a lot of people were disposing of manure on fields. So, they were creating a legacy phosphorous problem, which you’re applying more phosphorous on the land and it’s getting built up and built up and its way past the rate where it would be a benefit for crops, but that really was how they needed to dispose of the manure, so it’s a problem. You need to get rid of the waste somehow. But yeah, that algal bloom kind of happened first, and people really rallied around that and said, “okay, this is what we need to do. We need to find different ways of disposing of the manure and look at those phosphorous levels”. So, I think in some ways the, and other farmers and other parts of the state had seen that happen, so when algal blooms were happening in Lake Erie, I think farmers were maybe not that surprised. And I think there’s a research community that had seen a very large algal bloom in 2011. So, we knew that that had been the biggest bloom we had on record, up to that point. So, I think that the agricultural community and the research community had an idea that water quality was becoming an issue in the western Lake Erie basin, but the people that drank the water, they had no idea. They had no idea that this problem was looming. They had started testing for the cyanobacteria toxin and it had sort of been close to the level before, but it had never really triggered a shut down. What was different about 2014 was, I think, the wind patterns were keeping that bloom concentrated around the water intake, so even though it was as big of a bloom, it was more toxic. And I don’t think there’s really been a big water advisory that has happened since, and they’ve also upgraded the water treatment plant to be able to take out the toxin if it gets high. So, they’ve got more infrastructure invest. And then in those 3 days they just really had to wait for those levels to come back down. There was no treatment capacity for that at the time, and I think that was what really upsetting for people was not only did they know their water wasn’t safe, they had no idea when their water would be back, and when it would be safe to drink again. So, yes it was only 3 days, but it was a very stressful 3 days for everybody.

**John McMaine:** So, what do you think Anthony?

**Anthony Bly:** She explains that well. I don’t like using the word ‘disposing’ of manure.

**John McMaine:** Sure.

**Anthony Bly:** I just, you know, I do some education on that topic, and we have to change that mindset. Those nutrients of manure are very valuable.

**John McMaine:** Yeah, I think this is such a big discussion. I think it could take up a whole other episode.

**Anthony Bly:** Oh yeah. We could go a long ways on that one.

**John McMaine:** But, briefly, kind of what are you thinking on that? Kind of disposal versus what?

**Anthony Bly:** Well, it’s a commodity. It’s not a waste anymore.

**John McMaine:** Sure.

**Anthony Bly:** We shouldn’t look at it as a waste.

**John McMaine:** Yeah. Now, an environmentalist would say, ‘if we change the language, we’re just greenwashing the practice.’

**Anthony Bly:** Well, we have to change the perception of what manure is.

**John McMaine:** Okay.

**Anthony Bly:** We show them it has value, and they should treat it like a commodity. Then, hopefully, they will start doing that.

**John McMaine:** Right. And really, if we think about manure from a water quality perspective, there’s a few things; if we misapply it or overapply it, then we worry about it. And one of those of course is bacteria eating E. Coli and things like that, but the other big one is nutrients.

**Anthony Bly:** Correct.

**John McMaine:** And then there’s no difference, really, in application of synthetic fertilizer and manure.

No difference at all.

**John McMaine:** It comes down to nutrient content and matching that with what the plant needs.

**Anthony Bly:** Absolutely.

**John McMaine:** So, I want to touch briefly on nutrients in general. The biggest ones we think about from a water quality perspective is Nitrogen, specifically nitrate. That could be a whole other episode or two of, kind of, the nuance between nitrate, ammonia, ammonium nitrite. Like, the differentiation of compounds, nitrogen compounds and kind of why there is issues, and things like that.

**Anthony Bly:** Right.

**John McMaine:** But typically, when we think about water quality, we compare nitrate and phosphorus.

**Anthony Bly:** Mm-hm.

**John McMaine:** And I don’t think that’s a good comparison. Chad’s going to talk on this a bit more in a few minutes, but Lindsey differentiates these pretty well. We’ll get her take on this and the breakdown of phosphorus and nitrogen, and where they’re considered issues; freshwater, seawater, that type of thing.

**Anthony Bly:** Right.

**Lindsey Pease:** Phosphorous... it actually causes a similar problem to nitrogen in that it is a driver for harmful algal blooms, but the difference between algal blooms in freshwater and algal blooms in seawater is really just how the algae is processing the nutrients. So, in saltwater, Nitrogen is the limiting nutrients and that’s why all of the Mississippi river basin, everybody is focused on Nitrogen because that is the limiting nutrient. But for freshwater systems, you know, like Lake Erie, Lake Winnipeg, well lots of other lakes, Lake Superior even, phosphorous becomes the limiting nutrient for the algae. So, you want to be lowering your phosphorous inputs into lake systems.

**John McMaine:** So again, phosphorus is the limiting nutrient in freshwater systems and in some ways… I don’t know. It is challenging to treat phosphorus because once it’s in the system, it doesn’t cycle out. Nitrogen has a way to cycle out of the system.

**Anthony Bly:** Right. It transforms where phosphorus doesn’t.

**John McMaine:** Right, and so since this a conservation drainage season, we’re going to tie everything back to tile drainage and kind of see, you know, how tile drainage effects phosphorus loss, effects drainage systems. And historically, the common understanding, and this is still true, I shouldn’t say the science has changed we just know more now, but historically we’ve only seen phosphorus as a sediment problem.

**Anthony Bly:** Right.

**John McMaine:** Phosphorus sticks to sediment.

**Anthony Bly:** Mm-hm. It’s on our soil.

**John McMaine:** And so, it can build up in the soil, it stays in the soil, and so if you reduce erosion, you

**Anthony Bly:** reduce…

Phosphorus movement.

**John McMaine:** Phosphorus movement, and so if we look at tile drainage, we typically have less surface runoff because more of the water is getting in the system.

**Anthony Bly:** Infiltrating.

**John McMaine:** Infiltrating, you have more soil capacity there and so, conventionally we’ve looked at phosphorus loss in tile drainage and seen it as a way to reduce erosion. Then seen it as a way to reduce phosphorus loss.

**Anthony Bly:** Correct.

**John McMaine:** And that’s true for total phosphorus. But more recently when we started digging into… I say we and I mean the broader side of the scientific community. I had no part in this of course.

[Anthony laughs]

**John McMaine:** So, the broader side of the scientific community started digging into phosphorus in Lake Eerie and, you know, some of these freshwater watersheds.

**Anthony Bly:** Right, correct, yep.

**John McMaine:** And we see that there is actually a little bit, maybe, of dissolved reactive phosphorus. Or the phosphorus that’s in the water that comes out of tile drainage, or otherwise, and it just takes a little bit to…

**Anthony Bly:** To make a problem.

**John McMaine:** To make a problem.

**Anthony Bly:** Wow, yeah.

**John McMaine:** And so, I’m going to let Lindsey talk through, kind of, the relationship between tile and phosphorus, and then we’ll discuss that.

**Lindsey Pease:** I think that tile drainage definitely does contribute to phosphorous losses, and this was especially true where I was in Ohio. There’s a little bit of a difference, like how the water goes through the system in Ohio versus in, kind of the northern Great Plains where we are now, and it really has to do with the timing of when the tiles are flowing. Really in Ohio what you would see are low levels of phosphorous loss, but those tiles drain almost all year long and the ground doesn’t freeze. So, even in January, you’re still getting tile flow through those gravity outlets and so you get a really slow drip of phosphorous out of the tile lines, day after day. And over a whole year, that adds up to a bigger contribution to phosphorous loss than what you’re losing in the surface runoff, but that’s for drain fields. I still think that drainage can reduce phosphorous losses due to runoff, so it’s a bit of a trade-off. You’re reducing your runoff, but you are trading it for more tile flow. But then what we see or start to see as you start to move further North is that the tile flow is primarily happening during the growing season, except this winter was a little bit warm. So, it’s definitely going to depend on what the weather is like. If we don’t get the ground to freeze up, we’d still be losing a little bit every day. But for the most part, there is a good period of time in the northern Great Plains where the tiles aren’t flowing, so they’re going to be a little bit of a less contribution probably further north that you get.

**Anthony Bly:** Yeah, you know the climate really impacts that as well. We’re seeing that, those differences.

**John McMaine:** Yeah.

**Anthony Bly:** Yeah.

**John McMaine:** And so, yeah, things are going to change to as we see different climate patterns in different parts of the country. So, this past winter, so December 2020, January 2021, we were actually collecting tile samples during those winter months, in South Dakota.

**Anthony Bly:** Wow, yeah.

**John McMaine:** And so, if we get into situations like that then yeah it is, you know, maybe 12, maybe 10, maybe 11 months of the year that we’re getting some loading out of the system.

**Anthony Bly:** Some flow, yep.

**John McMaine:** Yep, so whereas historically, you know maybe it’s 9 months of the year, maybe it’s 8. You know, like it’s…

**Anthony Bly:** Well, we have less, you know, typically less precipitation too, so we don’t need to take water out all year long.

**John McMaine:** Right. So, I think too if we think about water movement through the system, right, as we get more, there’s potential for more loss. I mean there’s just more flux.

**Anthony Bly:** Right.

**John McMaine:** More potential for influx.

**Anthony Bly:** And we have that ability in our precipitation too.

**John McMaine:** Yeah.

**Anthony Bly:** The average isn’t what we get. It’s either high or it’s low.

**John McMaine:** Yeah, which creates all kinds of challenges.

**Anthony Bly:** Right. It’s not consistent.

**John McMaine:** So, Lindsey talked about, kind of, the constant drip or steady drip potential. The steady loss potential through phosphorus or tile, but I don’t want to give the misconception of when we looked at the total picture. So, I’ll let her give the big picture perspective relationship between tile drainage and phosphorus loss.

**Lindsey Pease:** From a big picture perspective, I would actually say that tile drainage reduces phosphorous loss because those surface runoff events can be really impactful in a way of releasing a lot of sediment and a lot of water from the ground surface, and at least if it’s filtering through the soil profile, it has the chance for some of that to filter out. It obviously doesn’t have to filter out everything. We do have preferential flow path, so some of that water is going to short circuit and basically act like surface runoff, even though it’s coming through the tile. But I think overall, what you’re doing with tile drainage is you’re creating space for water to infiltrate into the soil profile. That’s really beneficial for preventing some surface runoff events.

**John McMaine:** So, I don’t think anybody that tells you one way or the other is 100% correct. I mean there’s nuance to this issue.

**Anthony Bly:** Right.

**John McMaine:** So, total phosphorus loss generally decreases with tile drainage.

**Anthony Bly:** Correct.

**John McMaine:** Because you’re reducing that…

**Anthony Bly:** Erosion potential. Yep.

**John McMaine:** But soluble phosphorus has the potential to maybe increase with tile drainage because there’s a pathway for it to leave the system.

**Anthony Bly:** And I suppose that’s really controlled by the amount of phosphorus in the soil itself.

**John McMaine:** Yes, and I would defer to you on that because that’s your expertise.

[Anthony laughs]

**John McMaine:** But yeah, I think the more and more it builds up, the more potential there is for that equilibrium to shift towards pushing phosphorus into the water, out of the soil. And then when that happens, now it has the potential to leech and leave.

**Anthony Bly:** To move into the tile water.

**John McMaine:** So, we’re going to bring in Dr. Chad Penn and I’ll let him introduce himself and then give my personal history with Chad. He’s a great guy.

**Chad Penn:** My name’s Chad Penn. I’m a soil scientist, a soil chemist for the USDA Agricultural Research Service located at the National Soil Erosion Lab in West Lafayette on campus at Purdue. I’m also an adjunct professor in the Department of Agronomy.

**John McMaine:** So, Chad is actually… he was my soil chemist teacher or professor whenever I was at Oklahoma State and I mean, he’s great at a lot of stuff but I think of him most for phosphorus.

**Anthony Bly:** Phosphorus is his thing, yeah.

**John McMaine:** And phosphorus removal structures, but one of the other challenges related to phosphorus is the levels that we typically see are very low when we compare that to Nitrate.

**Anthony Bly:** P.P.B.’s (parts per billion)

**John McMaine:** Yeah right, the parts per billion range rather than the parts per million range so it’s, you know, 10 to 100 to 1,000 times less than what we see for nitrate.

**Anthony Bly:** Right.

**John McMaine:** And if you’re used to looking at nitrate numbers, you’re thinking you’re golden, right?

**Anthony Bly:** Right.

**John McMaine:** Because it’s so low, like it almost seems inconsequential.

**Anthony Bly:** Nonexistent.

**John McMaine:** Nonexistent, but I’m going to let Chad tell a story about, kind of why this is not the case and then we’ll discuss that too.

**Chad Penn:** I remember one time our nitrogen expert at Oklahoma state, somebody from the USDA, and she was talking about nitrogen and phosphorous losses, and they do a lot of monitoring at that station, as you know. And of course, she’s presenting concentrations of phosphorous, I remember the nitrogen expert raised his hand at the end and says, “So, it’s less than 0.1mg per liter, what’s the big deal? Why can’t we just turn our heads?” and he meant it, he really meant it and she didn’t have a good answer, you know? But the answer is phosphorous, and nitrogen are different. There’s dynamics in the soil is totally different and it takes different concentrations to cause environmental problems. And it just so happens that phosphorous; you only need a tiny bit of it to cause an algal bloom. And the problem with it is that we need a lot of it to grow crops, and if we lose a tiny bit of it... I mean most of what we apply stays in the soil, you know? It’s a very-very high or much more efficient in that regard, compared to nitrogen, you know? It stays put, but that tiny fraction that’s leaving is causing algal blooms, and I think that was partly the disconnect. Some people will treat it as if scientists of several decades ago were ignorant to phosphorous, “Oh they were so stupid, they didn’t understand that phosphorous was soluble and moving”. No, they absolutely understood it and those guys, they understood it better than we do now, okay? I am very confident in that. They understood it in great detail how it worked. What they didn’t know was that that little bit of phosphorous that was leaving was going to be detrimental to an aquatic system.

**Anthony Bly:** Phosphorus chemistry.

**John McMaine:** And so, I was actually looking up this recently and there were some, kind of, groundbreaking landmark studies or reviews that tried to look at what is causing algal blooms? Is it carbon, is it nitrogen, is it phosphorus? And so, prior to that, again if you’re looking at losses from a field, you can measure the losses, you can see the losses and if you compare it to… if you compare phosphorus to nitrogen then it’s inconsequential.

**Anthony Bly:** Very small.

**John McMaine:** Very small, and before we knew that phosphorus was the limiting nutrient, then it doesn’t seem like it’s an issue, but now we know that it again only takes a little bit to make a big difference.

**Anthony Bly:** Same thing in our soils too, I mean that’s why it’s NP.

**John McMaine:** Sure.

**Anthony Bly:** You know, phosphorus is a lot less than nitrogen.

**John McMaine:** Sure, so to me that’s one of the challenges from, I don’t know… would you say an education perspective of ‘hey, we’re not losing much phosphorus off a landscape…’

**Anthony Bly:** We don’t need to. Just a little bit.

**John McMaine:** Yeah. So, it’s hard from an education perspective. It’s hard from a treatment perspective, because it’s hard to also justify treating something that you’re just trickling out. I mean it’s like you put in a giant filter for an eye dropper type thing.

**Anthony Bly:** Yep.

**John McMaine:** So, that’s one of the challenges to me and then, the other challenge… another challenger, we’re going to get to two more, but another challenge is again the fact that phosphorus doesn’t cycle out of the system. I asked Lindsey about this and so, yeah, she really dug into this, kind of the chemical and the physical properties that just don’t allow phosphorus to leave the system they just kind of cycle within the system.

**Lindsey Pease:** You’ve got some phosphorous that is attached to sediment and erosion can be a really big issue in a lot of these watersheds too. So, you have phosphorous that’s dissolved in the water, some of it is readily available for uptake by the algae. But then you have other sediments that are slower to release, so the phosphorous might be bound pretty tightly to the soil when it enters the stream, but then overtime it can release so you see the release of phosphorous from lakebed sediments and it’s really all a chemistry based process, for the most part. Really dominated by those chemical interactions, so changes in pH and changes in concentration gradients, all of those things are going to let the sediment release phosphorous over time, so even what might be in the lake today might not be what’s in the lake in a week or in a month or in a year. People that study nitrogen say they like nitrogen better because it moves a lot more. I kind of like studying phosphorous because it doesn’t move. There are fewer pathways for it to move but that’s really true. Once you get high levels of phosphorous in a system, it really takes a long time for it to cycle out naturally. So, that’s kind of where we start to see long-term impacts of phosphorous detriment on water bodies.

**John McMaine:** So that’s challenge number two, to me. Once it’s there it’s there.

**Anthony Bly:** It’s there, right.

**John McMaine:** And so, I want to talk about Lake Mitchell. We talked about that at the beginning of the episode a little bit and I want to talk about Lake Mitchell a little more right now. Lake Mitchell, near Mitchell, South Dakota of course, home of the world’s only corn palace.

**Anthony Bly:** Right, right. And it’s a man-made lake.

**John McMaine:** It’s a man-made lake and one of the biggest challenges with it is the ratio of the drainage area to the actual lake area. I think it’s like 500 to 1 or something, I don’t know. My numbers can be off there, but…

**Anthony Bly:** It’s big.

**John McMaine:** It’s a really big drainage area going into a relatively small lake.

**Anthony Bly:** So, we’re concentrating a lot of stuff there.

**John McMaine:** Right. So, even if our upland practices and landscape was pristine, you’re still concentrating lots of nutrients and sediment in that small volume of water. Again, relatively. So, that’s a challenge for Lake Mitchell, but when it comes to phosphorus and then going back to this comparison of concentrations, the concentration of phosphorus in the water, it varies. Let’s say it varies between 0.6 and 0.8 parts per million.

**Anthony Bly:** Okay.

**John McMaine:** So, again, compare that to nitrate. The nitrate drinking water standard of 10 parts per million, well shoot. We’re over 10 times lower than that standard, than that benchmark.

**Anthony Bly:** Yep.

**John McMaine:** But for there not to be algal issues in Lake Mitchell, we need to be at 0.06 to 0.08, so ten times lower than what it is now. So, 100 times lower… over 100 times lower than the drinking water standard for nitrate.

**Anthony Bly:** Right.

**John McMaine:** So, that’s challenge number one. Challenge number two, if you look at the loading, so where the phosphorus is coming form that’s present in the water column. Around 47%... 45% - 47% of the loading of phosphorus in Lake Mitchell is internal.

**Anthony Bly:** It’s right there already.

**John McMaine:** So that means, yeah, it’s being released from sediment. It’s being released from organic matter; algae that’s decaying or whatever the case may be, and it just cycles back into the water column.

**Anthony Bly:** And that kind of usually happens when the water overturns in the lake?

**John McMaine:** So, it’s partly that. So, part of it is like a resuspension of sediment but part of it’s a gradient thing. As there’s less phosphorus in the water, then phosphorus from the sediment will move to the water, and part of it’s a chemical reaction thing as pH and things like that change, it will be released. But yeah, I mean there’s really no way to prevent it… I shouldn’t say there’s no way to prevent it but it’s challenging to prevent it. One thing you can try to do is to cap it with alum, and so that basically…

**Anthony Bly:** Seal it.

**John McMaine:** Yeah, basically seal it, flocculate that sediment, and settle it to the bottom and kind of seal over the top of that.

**Anthony Bly:** Lock it in, in a way.

**John McMaine:** Right, lock it in, but it’s temporary, it’s expensive, it’s challenging. Another way you can look at it is drudging it. So, actually removing the sediment, but man that’s a huge undertaking.

**Anthony Bly:** Oh big, big deals.

**John McMaine:** Yeah, so that’s the, I’d say, second challenge, a big challenge with phosphorus from a local example. And then, I’m going to let Chad talk about the third, what I view as the third challenge, and that’s kind of the variability of phosphorus loss.

**Chad Penn:** I mean it can change within an event, within a matter of minutes to hours. We do a lot of monitoring up in northern Indiana, particularly in the western basin and you’ll see concentrations of 0.1mg per liter of dissolved P coming through the top and then 30 minutes later it’s 1 mg per liter. And then as the event subsides, it’ll drop back down, so I guess the short answer is within an event, I guess it depends on how fast the water is moving through your system. Mark Williams and I worked a lot together on Mark being a hydrologist, that’s the sort of thing we’re trying to get at now is trying to understand the nature of is dissolved P-loss. And what we’re finding is that hydrology and the soil chemistry are dynamic. So, the hydrology will partly control the ability of the soil to serve as a sink for phosphorous and how it will behave as a source of phosphorous and how it can change.

**John McMaine:** So, it’s variable.

**Anthony Bly:** Yeah, so that makes it harder to treat.

**John McMaine:** Yeah, if you have an inconsistent flow concentration…

**Anthony Bly:** Right.

**John McMaine:** Yeah, and then a high concentration…

**Anthony Bly:** You’ve got to be ready for the big one.

**John McMaine:** And then the… also the fact that soil can act as either a sink… So, phosphorus can go from the water into the soil, …or it can act as a source. That depends on the concentration of phosphorus in the water, and that gradient, kind of between the water and the soil.

**Anthony Bly:** And the chemistry of the soil.

**John McMaine:** Right, and the chemistry of the soil.

**Anthony Bly:** Right, yep.

**John McMaine:** And so, this is a little bit of different context, but some of the work that I’ve done and that I’ve seen with bioretention cells… so, from an urban stormwater management perspective, we see that, and some of it… and basically, there will be phosphorus leaving the bioretention cell if the water coming in is low concentration phosphorus. So, basically if you have a low amount of phosphorus coming in, then it’s going to pick up whatever is in the soil, and then leave with that phosphorus. If you have a high concentration of phosphorus coming in, then it’s higher than what’s in the soil or in the media. Sometimes it’s an engineered media and so it’ll actually put phosphorus from the water into that media. And so, you… it’s hard to again manage inputs, and this is either in an ag-field or in an urban stormwater perspective, and then… so you have the input concentration, you have what’s in the soil, and like you said, the chemical characteristic, chemical makeup of the soil, and then how much phosphorus is already there. And then, like Chad says, it can vary even within an event to go from very low to very high, so yeah. So, those 3 things; the low concentration compared to nitrate.

**Anthony Bly:** Right.

**John McMaine:** Both from an education perspective as well as…

**Anthony Bly:** Monitoring!

**John McMaine:** Monitoring, right. And then when we get down to the analysis, like when we’re analyzing for this stuff, the lower it goes, the harder it is to accurately measure.

**Anthony Bly:** Correct.

**John McMaine:** So, then there’s error there… anyway that’s another…

**Anthony Bly:** Sampling error.

**John McMaine:** Right.

**Anthony Bly:** It just makes it more difficult.

**John McMaine:** Makes it more difficult… So, low concentrations, once it’s in the system it just cycles, and then the variability of it, and kind of the dependance on all these different factors. So, it’s a challenging beast, I’m glad that Lindsey is excited and ready to take on the challenge. It’s great to have those folks in the region and, kind of in the scientific field working on these very challenging, wicked problems, as we call them sometimes…

**Anthony Bly:** Grand challenges.

**John McMaine:** Grad challenges! Yeah, let’s call it a grand challenge. So, I think that’s a great place to stop for now. We kind of covered the basics around phosphorus, and then started with that really, kind of scary story about the Toledo Water Crisis and then next week we’re going to bring Chad into kind of talk about what he has seen as the increase in phosphorus loss and phosphorus loading and then we’ll get into your question, or your response about manure, and I think we’re going to have a really great discussion about manure and phosphorus. We’ll also have two more episodes after that on phosphorus removal structures and treatment, and kind of what the future looks like, but for now, as always thank you for joining us on Streamlines, your source for water knowledge. And again, if you’d like to learn more about phosphorus and its effects on water quality, find us on the SDSU extension website, or follow me on twitter: @SDSUextwaterman. For now, I’m John McMaine.

**Anthony Bly:** And I’m Anthony Bly.

**John McMaine:** And we’ll talk again soon.

**[Music]**