## Bioreactors and Your Bottom Line

## Season 1, Episode 3

[music]

**John McMaine:** Thanks for joining us on streamlines, your source for water knowledge. I’m your host John McMaine with South Dakota State University Extension. This is episode 3.

[music]

**John McMaine:** Welcome back everyone, I’m John McMaine.

**Anthony Bly:** And I’m Anthony Bly

**John McMaine:** And we are really, really excited to be recording our first podcast episode about bioreactors.

**Anthony Bly:** Woah, what a cool topic!

**John McMaine:** What a cool topic? So, what do you think about bioreactors, just off the top of your head, Anthony?

**Anthony Bly:** You know? I think they’re a wonderful tool for taking nitrates out of the water, tile water. I mean it’s unbelievable that we can use biochemistry to do that.

**John McMaine:** That’s a pretty fair point. I hear a lot of criticism about bioreactors. Do you hear a lot of criticism about bioreactors?

**Anthony Bly:** Well, probably not to the extent you do but lots of skepticism maybe, and what’s the cost, and ‘I’ve got to maintenance it again and clean it out’.

**John McMaine:** Yeah

**Anthony Bly:** You know?

**John McMaine:** Yeah

**Anthony Bly:** How do I know that it’s working?

**John McMaine:** So, I don’t know if you’ve looked in the literature much about how they perform and that type of thing, but I talked to Laura Christensen…

**Laura Christensen:** My name is Doctor Laura Christensen. I’m an assistant professor in the Department of Crop Sciences at the University of Illinois.

**John McMaine:** Yeah, so Laura works with bioreactors and in fact, I would say she’s one of the world’s leading experts on bioreactors. She has… well, I asked her what kind of stuff are you working on? And her answer was, ‘How much time do you’ve got?’ because she knows so many things about bioreactors and it’s really cool, but we started at the basics; How do bioreactors perform?

**Laura Christensen:** Well bioreactors work by enhancing a natural part of the nitrogen cycle; the process, the natural process of denitrification. Denitrification for all the crop advisors listening out there, they’ll be familiar with this process. Denitrification is the process we want to minimize in the field, but we want to maximize in a bioreactor. Denitrification is the process where nitrate, which is the specific form of nitrogen. Nitrate, either in the soil or in the water gets converted to nitrogen gas. Typically, dinitrogen gas. We know from 5th grade science class that dinitrogen gas makes up 78% of our atmosphere. So, it’s not a greenhouse gas, it’s just a natural stable gas in our atmosphere. So, in a bioreactor we want to maximize the process of denitrification and denitrification is actually a process that’s done by natural, good bacteria. Little bacteria that are actually called denitrifiers, as you would guess. These denitrifiers inside a bacteria or in the soil, they eat organic carbon and then as they have access to nitrate, they convert that nitrate to nitrogen gas. And in a bioreactor, they get their food, their organic carbon from the woodchips. And that’s why we call them woodchip bioreactors because it’s a trench full of woodchips. An important aspect that is sometimes glossed over or sometimes I forget to say, the process of denitrification and cleaning our water using that process of denitrification, it’s actually a biological water treatment or a biological water cleaning process, because it sees bacteria. It sees little good denitrifiers that are doing the water cleaning process and because it’s a biological process, that’s why we have the name Bioreactor.

**John McMaine:** Yeah, so that’s kind of the baseline of how a bioreactor works and like Laura said, really, it’s interesting and like you said it’s incredible because this is a system that we set up and it just happens. It’s not like we have to seed this bioreactor with any special type of bacteria or anything like that. It’s microbes that are there. I mean they’re doing this part of the nitrogen cycle and naturally fascinating to me. Then, another question I asked her was, ‘How do they perform?’ and honestly, results vary widely. Results vary from 5% reduction which is not something you want to see.

**Anthony Bly:** Nope, not worth it, no.

**John McMaine:** And all the way up to 99% or 100% reduction and the big reason or a couple of big reasons for that is, so variable one is the amount of water you’ve got coming in, right? So, your bioreactor size to be able to treat a certain peak flow of water. If you had significantly more than that, then all of that is going to bypass. So, that’s all that water you’re not going to be able to treat. Then, cold weather really affects bioreactors. Let’s go to Gary Feyereisen. Gary Feyereisen is with the Agricultural Research Services, ARS, in the twin cities and he really gets to this question of about how bioreactors are affected by cold weather.

**Anthony Bly:** Wow

**Gary Feyereisen:** My name is Gary Feyereisen. I’m a research agricultural engineer working for the USDA ARS in St. Paul, Minnesota. In our experiments at colder temperatures, and we’ve done one experiment at 2o Centigrade, 37o F or something like that, we see… we measure the DOC in the water and the affluent and it’s very low. Then, we get the idea that this reaction, this process is carbon limited and when we take the same wood chips and we add acetate to them, they were doing quite well. In the one published study, we had an HRT of an hour and a half. And I think we still got 30% of nitrate out under those conditions, so that just shows the denitrifiers are there. If you give them the carbon, they can do their work.

**John McMaine:** So, I want to dive into this a little bit. He mentioned HRT, hydraulic retention time or residence time

**Anthony Bly:** Wow, that is a big term.

**John McMaine:** Yeah, it is a big term, but it’s pretty simple. It’s how long it takes the water to get from the inlet to the outlet of a bioreactor.

**Anthony Bly:** Gotcha.

**John McMaine:** So, an hour and a half is, you know, it takes an hour and a half to go from the front end to go to the back end. Typically, we design bioreactors for 6-8 hour HRT, so one and a half hours is really…

**Anthony Bly:** Pretty quick.

**John McMaine:** It’s really quick and the thing he talked about with adding carbon; the situation here, they did it in a cold study and an hour and a half of HRT, and they still saw 30% reduction of nitrate.

**Anthony Bly:** That’s a big number for that short of time.

**John McMaine:** Right! For that short of time those cold conditions and what they found is it’s actually not the denitrifying bacteria that’s limited by the cold weather. They’re ready to go at 38oF or 37oF. What was the limiting factor was the carbon bacteria; the bacteria that are making that carbon available.

**Anthony Bly:** Oh.

**John McMaine:** So, whenever they added bio-available carbon in the form of acetate, well now those denitrifying bacteria are ready to go, so they can use that carbon and take off. So, it’s maybe not a situation of being too cold, it’s about the carbon being available because the carbon bacteria, the one, the stuff that’s too cold.

**Anthony Bly:** So, is this a surface area problem, do you need more surface area then as the efficiency of those carbon bacteria decrease?

**John McMaine:** So, that would be one way to look at it, the other is the type of carbon. Another thing that Gary talked about was the breakdown or the percentage of lignin cellulose and hemicellulose within the wood chip itself. Lignin is going to be the most robust aspect of that.

**Anthony Bly:** Stable?

**John McMaine:** Stable, yup, and so it’s going to stay around the longest. It’s going to be the hardest to make bio-available. So, some of the bioreactors that they’ve looked at are older, say 7, 8, or 10 years old. What they’re seeing in the woodchips is that it’s mostly lignin at this point. The carbon has used up all the cellulose, all the hemicellulose and so it’s not so much a surface area aspect as much as it is the type of carbon.

**Anthony Bly:** Carbon quality.

**John McMaine:** Carbon quality, exactly. That was a really interesting part; that the bioreactor performance is dependent on a lot of things and a lot of the things that we design it for like HRT, the amount of water it can treat, all those things are set in stone, but a lot of the things like mulch type, or size, particle distribution of mulch, that changes over time, right? Well, the mulch type doesn’t change over time, but that makeup of the mulch, the quality of that mulch can change over time. That’s something you start to see diminish over time is that the more bioavailable carbon pools get used up, then those denitrifiers can’t work with anything.

**Anthony Bly:** So, I’ve seen the construction of bioreactors and they’re very simple construction with simple materials. So, I’m wondering, do we need a vessel that can be more quickly removed and replaced than the carbon source exchanged more quickly?

**John McMaine:** That’s a really good point Anthony and I think that’s one of the biggest questions about how we scale these up, ‘How do we really make it easy to work with?’ and that’s another thing that Gary talked about was developing a modular system that you can even make in the factory, take out to the field, and then replace basically. Let’s listen to him talk about that.

**Gary Feyereisen:** The other thing that I think would help bioreactors is if they could be modularized, if you will. Where we would have an engineered module that could be put on site very quickly and efficiently. The engineering would have been done, they would have been almost like built in a factory and brought out to this site and just dropped in place. That would be a vison I would like to see realized.

**Anthony Bly:** I think that would be really neat.

**John McMaine:** Yeah! And honestly it allows for a lot of flexibility, right?

**Anthony Bly:** Yeah, you could stack them next to each other and design the size and add more modules.

**John McMaine:** Exactly, and the other thing that it allows you to do is experiment with different types of carbon sources. Another thing that people have looked at is, ‘What if you used corn cobs?’ I mean we’ve got a lot of corn cobs laying around and actually that’s another thing that Gary looked at. The amount of carbon that’s available from a field of corn, if you just look at the corn cobs. So, we can listen to him talk about that.

**Gary Feyereisen:** There’s something very compelling about using corn cobs that are right next to the device. We don’t have to take 10% of Minnesota’s forestry production down to Iowa to fill all their bioreactors. I’ve calculated the amount of carbon fixed in the corn cobs themselves and I think there’s plenty of carbon for multiple years, from each acre, to treat it’s own drainage. I think coming up with some efficient way to harvest and replenish that every few years would be a great system.

**Anthony Bly:** I know a farmer who did that, harvested corn cobs from the back of his combine.

**John McMaine:** Oh really?

**Anthony Bly:** So, it would be very simple.

**John McMaine:** Sure, and I guess the only downside with that, to me, is corn cobs are going to have more bioavailable carbon.

**Anthony Bly:** Right.

**John McMaine:** So that’s a good thing because now those denitrifying bacteria have a more consistent carbon source, but the downside is it gets used up faster.

**Anthony Bly:** So, we need a module system to replace them more quickly.

**John McMaine:** Right. So instead of lasting, say 10 years before your carbon source gets used up, it might last 3 years or 4 years. So, it would be a system that requires more maintenance, but you would get consistently better performance because again, that carbon is going to be available, more than the woodchips might be if you’re stuck with a lot of lignin.

**Anthony Bly:** So, what’s the value of the material that’s left over after it’s, so-called spent out?

**John McMaine:** So, the research of bioreactors that we’re looking, they’re kind of reaching that lifespan. Most of them have been in 8, 9, 10 years, so that carbon, the woodchips get excavated and really at that point it could just be land applied, I mean, it doesn’t really have any nutritional value necessarily. I mean it would be carbon obviously, but there’s not going to be any nitrogen or phosphorous in that. So, it doesn’t have a whole lot of fertility value, but at the same time, it’s not going to be any type of waste source.

**Anthony Bly:** Right. You could just put it right back on the land.

**John McMaine:** You could just put it right back on the land, so it could be incorporated as a carbon source.

**Anthony Bly:** One thing I hear him talk about, he mentioned credits.

**Gary Feyereisen:** I think the idea of trading credits, going back to producers to incent them to install these thing and pay attention to them would be a good thing. So we also have some work in that area where one thing good about this type of practice is we can measure the load coming in, the load going out; ‘You remove that much’ you know? Whereas some infield thing, you don’t really know. You have to go, ‘well this research study says it removes this much’ no, we can measure in and out.

**Anthony Bly:** What did he mean?

**John McMaine:** So that’s another big picture question about credits and how we value the ecosystem services that different practices provide. If we think about a bioreactor, yeah it doesn’t increase yields, it doesn’t really hold water in the field to make the system more resilient for the water.

**Anthony Bly:** It doesn’t give back the nitrogen.

**John McMaine:** It doesn’t give back the nitrogen, right. So, one way that we can value that, because it does have value right? It’s improving water quality, but we’re not valuing that currently. So, one way… big picture, future, forward looking, is that we can value that through some type of credit trading system. You’ve heard of carbon markets and things like that.

**Anthony Bly:** Yes, a lot.

**John McMaine:** Right? So, this would be a similar type of idea, to say, ‘Is there an entity, a stakeholder, a user in the watershed that maybe can’t make a permit requirement because of technical and feasibility and so, could they support implementation of a bioreactor that we can measure the reduction of nitrate through that bioreactor?’ and then they get credit through that. They help pay for it getting put in, and then the watershed as a whole still benefits because that nitrate is getting reduced.

**Anthony Bly:** No, that’s interesting. There’s got to be a way to figure out how to pay for these.

**John McMaine:** That’s right and that’s another interesting question. So, I want to bring in Keegan Kult.

**Keegan Kult:** Keegan Kult, the executive director over at the Ag Drainage Management Coalition; industry led group looking to advance the implementation of many of these conservation drainage practices.

**John McMaine:** So, Keegan works with a lot of practitioners. He’s kind of an interface between research and industry, putting practices in. One of the things that Keegan talked about was basically making it more worthwhile for contractors to be able to put these practices in.

**Keegan Kult:** Now I kind of focus on making these things as easy as possible to get in the ground. We’re looking in Polk County Saturated Buffer project. We’re also doing bioreactors within that, trying to kind of marry up cost share funds available. So, mixing state and federal, even some county level funding together to help pay for these things, and we’re really trying to take the burden off of the producer and the landowner. We’re bidding these things out in large packages so that we get contractors interested. Basically we just want the producers and landowners to be informed on what’s going on but they don’t have to come back into the office 4 or 5 times. We’ve gotten pretty good response on this. It’s kind of a different approach to conservation implementation in that we’re not doing a full conservation plan, we’re actually being very specific that we’re talking about these two edge-of-field practices in this project. This is in Polk County, Iowa, in 4 small watershed that we’re doing this in. Right now, we have over 60 sites with the green light to go ahead, to go towards insulation here. Hopefully next spring we’ll be starting these installs. You know, this is about a year long project and we’re going to nearly double the amount of these practices put in place in the state of Iowa.

**John McMaine:** Wow

**Keegan Kult:** In a single year.

**John McMaine:** And so now it makes it worth it to the contractor because, you know a bioreactor would be about $10,000 to put in. Saturated buffer of $3,500 to put in. It’s not really worth it for the contractor to mobilize his equipment, get the equipment out there, spend a day or two days putting that practice in, for only $10,000 bucks.

**Anthony Bly:** Right, you’ve got to have a bundle of other things.

**John McMaine:** Right, and so what they’re looking at is if they can have 30 bioreactors or 30 saturated buffers as a package deal, well now that’s a $200,000 job. So now it makes it worth the contractor’s time and investment to put in all those practices, so the question remains is how do these systems pay for themselves? How can we make it worthwhile to put a system in.

**Anthony Bly:** Actually, now tiles are running and there’s no incentive to do anything about the nitrates that are in it.

**John McMaine:** Right, exactly, and I don’t think that’s a question that’s going to get answered for a while. I think things would have to change or shift; paradigms would have to shift for that to change.

**Anthony Bly:** Absolutely.

**John McMaine:** I don’t think it’s that farmers don’t care about nitrate, absolutely. I mean, you farm.

**Anthony Bly:** Not at all.

**John McMaine:** Right.

**Anthony Bly:** Not at all.

**John McMaine:** And you care about nitrate and every farmer I talk to, that’s at the top of their mind, but there’s a lot of questions about… well there’s just a lot of questions.

**Anthony Bly:** Absolutely.

**John McMaine:** How do they work?

**Anthony Bly:** How do I know they’re working?

**John McMaine:** Exactly.

**Anthony Bly:** Right.

**John McMaine:** And so, until we get hard answers nailed down on that, I think it’s going to be hard for a farmer to adopt a practice that they may not trust.

**Anthony Bly:** Is there any way to put a dollar figure on value of the performance?

**John McMaine:** So, we kind of can. One thing that we can do is that we can say, ‘How much does it cost to remove one pound of nitrate?’ for example.

**Anthony Bly:** That’s what I want to know because the pound of nitrate going in is roughly $0.40.

**John McMaine:** Yeah, bioreactors are not going to be $0.40 to remove a pound of nitrate. It would be more in the range of $1 to $3.

**Anthony Bly:** Per pound of nitrate?

**John McMaine:** Per pound of nitrate.

**Anthony Bly:** Wow.

**John McMaine:** Then, whenever we compare this against other practices, bioreactors are actually one of the more… they’re pretty cost effective. Saturated buffers are really cost effective I would say because they require… it’s about $3,500 average, give or take, to put in a saturated buffer. $10,000 give or take, for a bioreactor, but they’re both simple passive system; they don’t require any input, don’t really require a lot of maintenance or operation throughout the year.

**Anthony Bly:** How does that compare though to management changes? Adopting new methods for determining more accurate nitrogen rates for corn, whether it be the PSNT test, maybe an active sensor as you apply nitrogen or some other things like that.

**John McMaine:** Yeah. Boy Anthony that’s a really good question and that’s one that I’m not really sure on. The biggest thing with those is those also reduce your input cost, and a bioreactor doesn’t do that. So, it’s challenging to say, put in a practice that, yeah it does a good job at removing nitrate and that’s what it’s designed to do, but it doesn’t help out your bottom line any because you’re not reducing your input cost.

**Anthony Bly:** Well, to me if it’s $1 or $1.30 per pound of nitrate to remove it and you paid $0.40 for it, you just added the cost of that nitrate and something on the farm has to pay for that.

**John McMaine:** Yeah, right.

**Anthony Bly:** If it’s not subsidized by society.

**John McMaine:** Right, and then what’s the value of not having that nitrate in the water?

**Anthony Bly:** So, the bioreactor in a sense is like a safety net.

**John McMaine:** Yeah, and that was one thing that Laura talked about too was we can do a lot of stuff in the field, and we need to do a lot of stuff in the field, those are all tools in the toolbox, but at the end of the day we’re likely still leaking nitrate out the tile. Then edge-of-field practices, that’s where those come in to say, ‘look, we’re losing nitrate potentially, what can we do with the edge of the field to prevent that from continuing on down the stream?’

**Anthony Bly:** Sure.

**Laura Christensen:** The question is loaded with political and market and economic and social, social issues for sure. Some of the farmers that we work with for our on-farm bioreactor network, they really are early adopters, like you said. They are trying a lot of different practices across their farms, and they tend to be real innovators within their local agricultural communities and just within their local communities in general, always serving as a real positive voice for agriculture and trying to demonstrate how farms and how farmers really do want to be good upstream neighbors. So, moving beyond that, I think it’s going to take more research. At a basic level, to demonstrate that tile drainage does contain nitrogen, I think at a very basic level there’s still some doubt that tile drainage water maybe because it just tends to be very clear, could contain nitrate, and so there’s education that we need to do as part of our university extension services, and others across the state who do outreach just to illustrate the point and communicate the idea that tile drainage does contain nitrate, and that we are sending that downstream. Then, there is also research and outreach to be done to demonstrate how effective bioreactors are and that these are the conservation practices. I think there is some doubt and uncertainty about how well our conservation practices work, and of course there’s scientific uncertainty about some of our conservation practices too because they don’t always perform the same and then every year a cover crop doesn’t always perform the same in every year for producing nitrogen loss, or for building soil health. And so, I think there’s more research and more communication to be done around the idea of conservation practices and the benefits that we can provide on farm, as well as benefits that we can provide to our downstream neighbors.

**Anthony Bly:** It’s a cultural issue.

**John McMaine:** It is and how do you change culture?

**Anthony Bly:** Yeah, that’s tough.

**John McMaine:** I don’t know the answer, how we scale bioreactors up. I don’t even know if we need to scale bioreactors but I think we do need to think about how bioreactors fit in the big picture. Like you said Anthony, we can do a lot in the field but bioreactors are kind of like a safety net.

**Anthony Bly:** The fact is the nitrate is still in the tile water.

**John McMaine:** And sometimes, in very real economic dollars.

**Anthony Bly:** Yeah, there’s shrimp farmers in the gulf of Mexico…

**John McMaine:** or, and not to bring up a lawsuit but the Des Moines Water Works, that was kind of the primary impetus for that was cost to treat nitrate, excess nitrate in the raw water source.

**Anthony Bly:** In the water, yeah.

**John McMaine:** But, at the same time, like you said, it has to pay.

**Anthony Bly:** That’s the way a farmer is going to look at it, because they pay the bills to put their crop in and now, they’re going to pay a bill to take something out that is coming from their land.

**John McMaine:** Right.

**Anthony Bly:** And it’s a direct nitrate and nitrogen thing.

**John McMaine:** Right, and the challenge with that though, is that even if a farmer did every practice in the field, there’s still variability and there’s still likely loss. How do we value, not sending nitrate downstream and then how do we help that not happen? It does make a lot of sense to be as efficient as possible in the field and I think people do that, they want to do that, but there’s trade-offs to everything. Then, what if you don’t get any rain? What if you get too much rain? What if you get disease pressure in your corn crop? It doesn’t use as much nitrogen and is susceptible to be lost.

**Anthony Bly:** Absolutely. Things that are beyond our control.

**John McMaine:** Yeah.

**Anthony Bly:** So, it’s a safety net.

**John McMaine:** It’s a safety net. So, let’s talk about sediment in bioreactors. One of the challenges for a bioreactor is maintaining its design capacity. One of the things that can kill that is sediment, so if you get sediment in a bioreactor then you… well think about that. That’s the first one or two feet gets clogged up, then…

**Anthony Bly:** Water is not going to flow through it correctly.

**John McMaine:** Exactly. So, not only can it reduce your efficiency, but it can actually lead to production of things that you don’t want like nitrous oxide, and methylated mercury, and hydrogen sulfide and just really bad stuff. So, sediment is just really challenging and a potential issue for bioreactors. Especially if there’s any surface inlets for the tile system. One of the things that Gary Feyereisen talked about was, the studies that they’ve done. They’ve done a couple studies and they weren’t looking at sediment at all, but then the first little bit of the study they had a really big storm, a really big flush of sediment that just wreaked havoc on the bioreactor.

**Gary Feyereisen:** In this particular bioreactor was put on what I think is the largest watershed that I know of at least in the Midwest here. It was a square mile, so even though there wasn’t any surface inlets in the fields, there were in the road ditches. So, this is a problem and one of the other challenges with bioreactors or any of these practices is the frequency of these mega storms and this particular system had a 6+ inch storm brought sediment in and it begins to… we’ve done an autopsy on the bioreactor and it plugs right around the inlet manifold. It had actually happened to us and we weren’t sure what was going on in the first year of operation and over time, the water was able to carry that sediment further down the bed so that it recovered, but after that mega storm it did not recover. The sediment was deposited immediately outside the inlet manifold.

**Anthony Bly:** So, that’s the issue was surface inlets.

**John McMaine:** That’s a potential issue for surface inlets or if you have, like a blow out…

**Anthony Bly:** Yes.

**John McMaine:** …and you get a big flush of sediment through the tile system, well that has potential to go in your bioreactor, and then you have to totally redo your bioreactor.

**Anthony Bly:** So, I was just thinking that module system would really be handy then; you could pull out the first couple modules then check them out, replace them, or whatever.

**John McMaine:** Absolutely.

**Anthony Bly:** Yeah.

**John McMaine:** I think that’s a really big plus for the module systems. The other thing with modules is the first say 10 feet of the bioreactor, that’s the part that’s going to have the most activity, going to have the most sediment, so like you say if you could replace that first 10 feet, yeah that would be all you need.

**Anthony Bly:** I wouldn’t want to spend $15- or $20,000 on a bioreactor and then not know if that happened or not.

**John McMaine:** I mean, bioreactors do have a lot of challenges, right? They don’t provide any benefit directly to the farmer. They susceptible to plugging or clogging by sediment. They are variable performance, right? There are a lot of potential challenges.

**Anthony Bly:** Yes.

**John McMaine:** But I’m really excited about the potential next steps for bioreactors, kind of the new frontiers for bioreactors. And it includes some of the things we talked about. So, modules, that’s a big potential.

**Anthony Bly:** Absolutely, harvesting the corn stalks, or the corn cobs.

**John McMaine:** Yeah, and then another really cool thing; this was something Laura Christensen was really excited about was the many different potential applications worldwide for bioreactors.

**Laura Christensen:** One of the biggest things I find that motivate me about bioreactors, is when I hear about new applications for bioreactors and bioreactors being trialed in new areas around the world, on farms or in different applications. For example, fish farmers in Denmark are doing bioreactors. Bioreactors are being trialed in Spain; basically, desalinization brine, because farmers in certain areas of Spain actually desalinize their irrigation water and it ends up having very concentrated amounts of nitrate in it. This is a technology that could work really well in that application. Farmers in Australia and Queensland, Australia are doing sugar cane, pineapples, and horticultural crops. They’re really looking for solutions towards nitrogen loss, which is causing problems for the Great Barrier Reef. So, I get really excited when I hear of new applications. Farmers everywhere are looking for solutions to be better environmental stewards.

**John McMaine:** Then Gary talked about microbes, potential with microbes and targeting those.

**Gary Feyereisen:** One thing I didn’t mention that we have tried working in collaboration with the University of Minnesota, great microbiologists, they sorted through microbes and tried to select ones they felt would work well. We inoculated some beds in the field, some pilot beds, and we tried our approach to that. It was very difficult. The approach, it looked like we had some improvement for maybe a few weeks, but then the microbial community comes back to its original composition. It’s difficult for an introduced community to break in and thrive over time.

**John McMaine:** Yeah, I guess that wasn’t positive.

**Anthony Bly:** No, that’s okay I think all of the research being done is very positive because you need to weed through some of those issues, and you’ve got to keep foraging ahead.

**John McMaine:** It was really interesting, again, to talk to Keegan because his perspective is, it’s not a research perspective, right? He’s working with producers, he’s working with contractors, he’s working with industry that makes tile and really the people doing a lot of the implementation and work. So, Keegan was surprised at the farmer response related to bioreactors. Anyways, let’s just hear what he had to say about that.

**Keegan Kult:** Bioreactors are kind of in the practice that people feel the most uneasy about because it is very specific for nitrate removal. We don’t get some of those multi-benefits, but I still think it’s a great practice because it’s such a generalist; we don’t need a screen door with an outlet right there, we can actually put it at the edge of a field where the tile is going down to the next neighbor’s field so we can start getting that treatment back up higher in the watershed profile. Farmers are interested in doing it, small, relatively small footprint of it, it doesn’t seem to bother them. I’ve had farmers, more than I thought, actually willing to take out some of their head-rows to put a bioreactor in because they’ll be like, ‘oh yeah, just 100 feet long, 20 feet wide? Yeah we can do that, that’s not a problem. We can just hay it right there.’ So I think there’s a lot of opportunities out there for bioreactors and it will still be a practice that people are looking at getting it in place going forward.

**John McMaine:** I would say that’s one of the biggest benefits of a bioreactor is its flexibility. You can – rule of thumb – put it in for $10,000 and it will last ten years. $1,000 a year; you don’t even have to think about it.

**Anthony Bly:** Right.

**John McMaine:** It’s removing nitrate while you sleep basically. And like Keegan said, it’s very flexible in terms of where it goes in and the amount of space it takes. So, to me, that’s why bioreactors are still a valuable tool

**Anthony Bly:** Absolutely

[music]

**John McMaine:** Thanks for joining us today on Streamlines. We sure had a lot of fun today, hope you did too. If you want to learn more about anything you heard today, head on over to the SDSU extension website, but for now, I’m John McMaine

**Anthony Bly:** I’m Anthony Bly

**John McMaine:** And we’ll catch you next time.