Intro:

You are listening to Making Waves, fresh ideas in freshwater science. Making Waves is a bimonthly podcast where we discuss new ideas in freshwater science and why they matter to you.

Julie Kelso:

Hi, I'm Julie Kelso, your host for this episode of Making Waves. Last month I attended the American Geophysical Union meeting in New Orleans and I interviewed Dr. Juliana D'Andrilli about her research with dissolved organic matter. First I wanted to know what exactly is dissolved organic matter. And also since AGU is a meeting with tons of people from many different fields of earth science, I asked Juliana how she thought researchers from across disciplines might perceive DOM differently. You'll also hear me reference her quilt poster, which she presented last year at SFS, which focused on sewing together different studies involving DOM.

Julie Kelso:

So picture yourself in a long hallway in the New Orleans conference center with scientists and AV technicians walking around talking and making noise, which you will hear in the background of our conversation. The interview starts with me asking Juliana a simple question, what do you do and why do you do it?

Juliana D'Andrilli:

What I do and why I do it. I do research relevant to global carbon cycling. I got started thinking about carbon at a young age based off the works of Carl Sagan and the greenhouse effect. Through the ideas of different carbon cycling processes, I became very interested in working with a certain portion of the carbon cycle, mainly the large reservoirs of carbon stored and transformed as dissolved organic matter. In these pools we have specific types of reservoirs. We'll have frozen reservoirs and ice. We'll have aqueous reservoirs, and these are large, large stores of carbon that get transformed by microbes or the energy units of microbes. They'll get photo oxidized by sunlight. They participate in a lot of different reactions that become very relevant in terms of how our earth system processes work, how carbon is stored, how carbon is transformed, and how we're ultimately contributing to carbon in the atmosphere. So CO2 emissions and furthering our greenhouse effect on this planet.

Julie Kelso:

So I tell me more about how Carl Sagan played into this.

Juliana D'Andrilli:

Definitely. While I was an undergraduate student, I befriended a physicist. I took an awful lot of physics courses along with my chemical coursework. I am a physical chemist by discipline. I have a great passion for both disciplines and my physicist friend passed along a book to me by a Carl Sagan called Cosmos that I'm sure everybody is familiar with. And through reading that book and following a lot of his other literary efforts, I really fell in love with the way that he communicates. The most important things we need to learn about how the earth works and how our universe functions, to not only inspire scientists to keep working, but also to the general public to stay interested in environmentally relevant procedures and processes. We live all together. We all live on this one place. Nobody lives somewhere else. We are all on this earth together and I fell in love with learning about what is so special about our earth.

Juliana D'Andrilli:

So by the time I got to graduate school, I met a scientist named Bill Cooper and he sat me down in his office and said, "Okay, so you got to Florida State University, what are you interested in working on?" I said, "I've been following a lot of research on Carl Sagan's work. The greenhouse effect has particularly piqued my interest. Carbon emissions and carbon storage is something that I feel like I would really enjoy contributing to." He said, "Well, you've come to the right place. We study dissolved organic matter here in the Cooper group at FSU. And in this group we're really interested in characterizing the different types of carbon through very specific analytical techniques that informs us more about metabolic pathways, photo oxidative pathways, so that we can ultimately scale up to how this material affects atmospheric processes."

Julie Kelso:

Cool. So that's how you started your dissolved organic matter journey?

Juliana D'Andrilli:

Absolutely. So the journey began thinking about molecular composition of dissolved organic matter. We wound up starting at a very microscopic scale and scaling back to bulk properties as well. So we're interested in carbon quantity. We're interested in carbon quality. Not only how much of the material is in the environment, in different phases, but what types of materials are more prone to be metabolized or transformed throughout the environment.

Julie Kelso:

So when people ask you what do you study, you say dissolved organic matter?

Juliana D'Andrilli:

Sure.

Julie Kelso:

So what is dissolved organic matter?

Juliana D'Andrilli:

Sure. More often than not, I'll start by taking a biogeochemical approach to carbon cycling in the environment, which essentially breaks down into the carbon characterization of the dissolved organic matter. Dissolved organic matter can be operationally defined using a filtration apparatus. Anything that's less than one micrometer size in terms of a pore size is then going to be considered our dissolved fraction. So is it large in terms of microscopic scales? Yes, it's still pretty big. But it's not going to be like a sediment particle or something that you can actually see physically with your eyes when you look into an aquatic ecosystem.

Juliana D'Andrilli:

Now that being said, I'm sure a lot of us have gone to freshwater ecosystems, gone fishing, guns, swimming or kayaking and pulled up a pool of water in our hands and seen like a tinge of yellow or a hint of an orange color in the water. These tannin light colors are informing us that there are a lot of organic matter constituents in the water column. So while we cannot see the molecular constituents with our naked eye, we certainly can see its build up.

Julie Kelso:

But what is it?

Juliana D'Andrilli:

Okay. What is dissolved organic matter? Dissolved organic matter is a grouping of chemical constituents that perform a function as energy substrates from microbes. Microbes are going to want to metabolize this material to sustain life. They're going to find juicy types of organic matter or organic matter constituents that they need to work towards breaking down to sustain their metabolisms in different environments.

Julie Kelso:

So you think it's an energy source for microbes?

Juliana D'Andrilli:

Energy source. Yes, definitely. Participates in a brilliant microbial loop both in freshwater and in marine aquatic ecosystems. Without it, we would not be able to sustain carbon turnover rates, bacterial life, and the lowest levels of our trophic ecosystems. When we follow this type of material up the food web, we can have microbially produced organic matter exudates. We can have organic matter constituents from the decay of terrestrial ecosystems as well. So higher plant, detrital material, anything that is basically formed or decayed by biomatter that enters our ecosystem.

Julie Kelso:

So when you think of the juicy forms, what do you think of?

Juliana D'Andrilli:

Okay. That's a great question because juicy to a chemist probably means something different than maybe to a physicist or a biologist. I think about a juicy form of carbon or dissolved organic matter constituent as something that requires the least amount of energy for a microbe to break down, to get more energy out of to sustain life. To a chemist that may be an aliphatic molecule. That may be less of an aromatic containing constituent, so that the microbes don't have to work as hard.

Julie Kelso:

You think a physicists or biologists would define juicy a different way?

Juliana D'Andrilli:

Well, I have spoken with a lot of microbiologists that talk about letting the microbes decide what's juicy to them. So from a chemist perspective, I like to characterize carbon in terms of its molecular composition. So how many carbons, hydrogens, nitrogens, oxygen, sulfurs, atoms containing species. And I like to take that information and group it into what, from a chemist perspective might be, okay, this is more aliphatic in nature, less aromatic in nature, potentially more juicy towards a microbes perspective. But a biologist would say, let the microbes select for those types of constituents or any constituents that they might seem would be energy rich for them to break down and metabolize. From that perspective they would not have a chemical category to outline that. So juicy just means different things to different people.

Julie Kelso:

So it might just be what they ate first.

Juliana D'Andrilli:

Absolutely. I'd say what they eat first and what they preferentially work through. There are certainly different types of chemical constituents that would be broken down that people have assumed would be particularly recalcitrant, not so juicy for a microbe. However, that type of material can participate in different reactions can be broken down into different pieces that might then be more favorable for a microbe. So from a biologist perspective, they might say, "Wait until the microbes decide what types of materials they would like to metabolize." But from a chemist perspective, if we're only measuring the chemistry of DOM, we're interested in looking at double bonds, single bonds, aromatic rings, and then defining those types of bonding and those types of molecular confirmations as whether or not they're more energy rich or more energy difficult to break down for a microbe.

Julie Kelso:

Well, what I'm wondering is how can we better bring all these disciplines that use dissolved organic matter to figure out what it is. Engineers, terrestrial biogeochemists. There's so many different ways to get at that problem of, what is DOM. How can we better bring the community together?

Juliana D'Andrilli:

That's a great question. I have thought about using an approach similar to what we're doing here at the American Geophysical Union meeting where we're gathering diverse ecosystem approaches using similar techniques to talk about the challenges with the way we're thinking about characterizing DOM chemistry. Either from a biological side, a chemical side, or a physical side, and how we can come all together to continue a dialogue. How can we communicate throughout the year on different projects to better understand these types of things? For a few years, I would say in the last decade, it seemed like a lot of communication was very separated. Very diverse, but very separated. Different research groups really weren't actively communicating with each other. It was more about separate research projects in separate places. I think the benefit of these meetings and the benefit of workshops and webinars and continuing dialogues throughout the year, getting differences of opinions. We can all have different opinions and we can think about these ecosystems and diverse ecosystems in really different ways. When it comes down to it, we're all really interested in how these earth processes work.

Julie Kelso:

So can you think of an example of a cross disciplinary aha moment that you experienced or you saw someone else experience?

Juliana D'Andrilli:

Sure. A few years ago I was fortunate to work with two ecosystem ecologists and a microbiologist so that we were approaching an interdisciplinary research project from completely different sides of the spectrum. Coming from my graduate degree focused on DOM chemistry alone. Thinking a little bit about what types of microbial processes might be changing the carbon chemistry studied in Minnesota peat lands. This was a huge aha moment for me. I have been feeling like we've been missing these components for maybe a decade or so. It's not just going to be about identity. We can't just identify dissolved organic matter and say, "There it is. We found it." We have to go beyond that. We have to say, "What type is it? What's it doing? Is it moving?" Then we have to talk to different scientists about what types of pathways might it interact with.

Juliana D'Andrilli:

I'm going to need to talk to microbial scientists. We're going to need to fill in these gaps, keep our loops closed so that we're understanding the entire carbon cycle instead of pieces of the puzzle or portions of the pie. So that big aha moment came for me when I coupled ecosystem ecology research with microbiology research and carbon chemistry research.

Julie Kelso:

Cool. Yeah. I'm thinking about your quilt poster. Do you want to maybe just describe that kind of concept?

Juliana D'Andrilli:

Sure. That was another aha moment where we really wanted to use a connected approach, like a synthesis quilt idea. If we stitch through different projects, can we better understand an ecosystem when we have all the aspects of a watershed connected to each other? So over the last seven years I've worked with precipitation samples. I've worked with geothermally fed rivers, I've worked with snow and ice, I've worked with headwater streams, larger order rivers, floodplain sediments, and river water, and then agricultural soils.

Juliana D'Andrilli:

So thinking about dissolved organic matter from the atmosphere, stage one, formation in the atmosphere, precipitation getting through an entire ecosystem from an entire watershed approach, we can sew together the connected nature of when a terrestrial ecosystem impacts the aquatic ecosystem and when they're disconnected. So that was going to be, I think, there were seven projects ... there were eight projects on that quilted idea. We found that a lot of the fluorescent nature of organic material was more connected when a terrestrial and aquatic ecosystem were coupled together. When the terrestrial ecosystem was not coupled with aquatic ecosystem, we found completely different organic matter signatures.

Juliana D'Andrilli:

That means that in snow and ice and headwaters streams and geothermally fed streams and rivers, we found completely different carbon signatures that dominate the types of quality that are found there versus agricultural soils, large order rivers, floodplain sediments, et cetera. That was going to be driven by terrestrial organic matter signatures. If you sew all these ideas together, not only do you develop an understanding of all the different components that play a role throughout a watershed, but also how they connect to each other.

Julie Kelso:

So one other thing that I have been thinking about is sharing methods and concepts across fields. For example, freshwater DOM science has pulled a lot from marine DOM science. So are there any new or emerging methods you're excited about or wish you had known about earlier?

Juliana D'Andrilli:

A few different things that I would suggest in terms of methods across different disciplines. Whole water experiments are great. They give you a lot of information. Should we stop at the end of whole water grab samples? Probably not. We should probably investigate the different pieces of the whole water by doing chemical separations or testing how it responds to different temperature controls or pH levels. We should be pushing the boundaries of understanding it as best we can.

Juliana D'Andrilli:

I think we're not exposed to a lot of these different methods at the outset. The things that I was exposed to as a chemist fortunately have been pretty applicable for dissolved organic matter, chemical work. But there are things that I did not think about that I have been saying, "Why didn't we do this 10 years ago?" And chemical separations is one of those things. For a lot of the research that people conduct on dissolved organic matter whole water samples, it's important to stick to the big picture. I think we need to couple these big picture experiments with smaller pieces of the puzzle. We need to be using different techniques to probe the fractions inside of the whole water samples so that we can understand them a little bit better.

Julie Kelso:

Well, one field of study that I didn't know about and I found interesting was your research looking at airborne ice nucleating particles.

Juliana D'Andrilli:

Yes. I'm on a collaborative project with Dr. Brent Christner from the University of Florida and he synthesized a proposal that specifically focused on ice nucleating particles in the atmosphere. I talked to him about this project and I asked if he was looking at the dissolved organic matter chemistry of the precipitation we're going to be collecting a ton of precipitation in different rain events in Louisiana area. Why not couple of the biological aspect with the dissolved organic matter chemical aspect? Because those two are going to be completely interwoven and he the idea a lot and the graduate student on the project, Rachel Joyce is working on developing not only the ice nucleating particle information. So the biological information quantity, different types of bacteria when they're most prevalent, different types of air masses that they seem to either prefer and which temperatures that seem to propagate different types of ice nucleating particles, but also tracking back where the storms originated from. So does the DOM chemistry and does the biology get effected by the regional or origin of these air masses.

Julie Kelso:

So after attending AGU and meeting so many different people, what new research ideas do you think are going to be keeping you up at night?

Juliana D'Andrilli:

What's going to keep me up this weekend in particular are going to be two ideas that have just recently been developed by being at this meeting and speaking with three or four different scientists from other universities and research institutes. We have two separate ideas that we're really interested in and I won't go into too many details there. But I will say that the fascinating ideas of ecological impacts from cryosphere changes is going to be keeping me up at night for a good long time. We're really interested in networking together and getting great publications out there that communicate not only that the earth is changing and we have increased temperatures. Climate is changing. But we can test for what types of ecological impacts might be happening. You can do that right now. We don't have to wait. You can collect samples right now and we can run those tests. A lot of people are very interested in dissolved organic matter chemistry and transformation and localized environments, and then they scale to a global perspective.

Juliana D'Andrilli:

Why aren't we measuring the global perspective? That's keeping me up right now? Let's take those samples. Let's go to these places and let's do a unified approach so that when we scale back up to different case scenarios, let's say in two degrees Celsius temperature rise or more, we actually have some quantifiable numbers to go along with it.

Julie Kelso:

Well, thank you Juliana, for taking the time to speak to us about DOM and with that, this is Julie Kelso for Making Waves podcast with the Society for Freshwater Science.

Outro:

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