Eric Moody:

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Eric Moody:

This is Eric Moody with the Making Waves podcast for the Society for Freshwater Science. This month I'll be talking with Dr. Miguel Cañedo-Argüelles, who is a post-doctoral researcher at the University of Barcelona. Among other things, his research has focused on the effects of reverse salinization on biotic communities and freshwater environments. Thanks for joining me Miguel.

Miguel Cañedo-Argüelles:

Yeah, thank you very much for the invitation Eric.

Eric Moody:

My first question for you is, what exactly is reverse salinization or freshwater salinization? What causes this process to happen?

Miguel Cañedo-Argüelles:

Basically, this is a good question because we use the term a lot. Basically we use it as the increase in dissolved ions or in the US we use the term total dissolved solids, but in the end it's just increase in dissolved salts in rivers. This comes from a lot of different activities, human activities.

Miguel Cañedo-Argüelles:

I think that the most documented issue is land clearing in Australia. Most of the papers, important papers, early papers come from Australia because they have saline ground waters. The groundwater in many parts of Australia has salts dissolved in it naturally, and so when they clear the trees and they replace it by crops and other kind of vegetation that does not retain water, then the groundwater came up with all those dissolved salts in it and it caused salinization of rivers. That was one of the most important courses, the replace of trees and vegetation by crops and pasture in Australia.

Miguel Cañedo-Argüelles:

Then more and more cases have been documented and many other different causes have arose. For example, mining, coal mining, there in the US you have the Appalachian in many other regions, but especially that region in Virginia, where you have a lot of coal mining. Because of coal mining there is a lot of rocks that are being exposed to the weathering of the rain and the climate, and that leads to salinization too. Then you have different types of mining, all of them usually lead to salinization.

Miguel Cañedo-Argüelles:

Then you have gas extraction, agriculture. In the Northern regions you have the use of salts or for roads to prevent icing in the winter. That's a huge cause of salinization in cold regions. In the end there is a lot of different factors, also wastewater treatment plants. The wastewater coming from the cities, they also have high concentrations of water, many different industries like textile industries. In the end there is a lot of causes sometimes interacting between them, and it's a widespread phenomenon because in some places you have main cause might be agriculture, another place might be road salts.

Miguel Cañedo-Argüelles:

I just want to say that, when we talk about salinization, we mostly refer to this increase in salts, but it's not only that. It's also important to acknowledge that we are changing the ionic composition of the water because many of these salts are sodium chloride or other types of salts that might be not as abundant. It's not only an increase in the amount of salts, but it's also that you might be changing the balance of ions in the water and that's important for freshwater organisms.

Eric Moody:

You mentioned a number of causes of salinization and I was wondering if different causes could be depositing different ions or different salts in the water. If you see different effects as a result of road salt versus potash mining or things like that.

Miguel Cañedo-Argüelles:

Yeah, that's a good question and definitely. To put a very simple example, mining itself, it depends what kind of mining, you will get different kind of ions. For example, when we talk about coal mining, a lot of the ions that will go into waters are sulfate ions. When you talk about potash mining, 90% of it would be sodium chloride. That is very different and the toxicity of these ions can be very different too. There is not much research about it, but there are more and more status being published and all of them are reporting that different salts have different toxicity.

Miguel Cañedo-Argüelles:

Yeah, totally different ions depending on the activity that you have. It would be really good to characterize the ions that are more abundant for each kind of activity, that's something that would be really nice to have that information. We still don't have that kind of information for a lot of human activities.

Eric Moody:

Let's just back up just a little bit. The defining characteristic of freshwater habitats is that they're low in salinity naturally in contrast to the ocean. Why is it that freshwater organisms have such a hard time dealing with these salts when other animals and plants can live in the ocean with these high salt concentrations?

Miguel Cañedo-Argüelles:

That's a really good question and a challenging question. It's something that more and more people is looking at now is how the osmoregulation functions in for example, freshwater insects. There is people like David Buchwalter in North Carolina, he's doing great studies about that. Ben Kefford just published a really nice paper about this. It contains a lot between different organisms, even within the same family or in the same order.

Miguel Cañedo-Argüelles:

Rivers have very low concentrations of salts naturally if you go for example, to headwaters streams, right? Sometimes it's like insects are living in an environment that is not really perfect for them in that sense. If you put a little bit more salt into water, actually you could be benefiting aquatic insects because they need to capture salt from the water to have ion balance between their internal media, their blood and the salts that are outside in the external media.

Miguel Cañedo-Argüelles:

We are talking about a very small increase, but then when you go over that point that let's say like optimal concentration of salt, everything starts to collapse. Basically, it's something quite simple, we need to keep a balance. All organisms, we need to keep a balance, an osmotic balance because of the pressure between our internal fluids and the external fluids.

Miguel Cañedo-Argüelles:

Aquatic insects or any aquatic organism has to keep this balance. Then if there are more and more ions in the water, then you need to spend a lot of energy into osmoregulation to keep this balance, to maintain this balance. This energy that you are spending on this, this energy that you cannot use for other things like for example, growing or even moving. At some point it's not only that you are having energy cost, but these mechanisms are like saturated and are not functioning anymore and they collapse. The moment they collapse is when the organism dies.

Miguel Cañedo-Argüelles:

I think that your question was also about more like the evolutionary perspective in this, right?

Eric Moody:

Right.

Miguel Cañedo-Argüelles:

I don't know much about that, but from what I've read, it's one of the things that is still barely known. Like why, from an evolutionary perspective, why is it so hard for freshwater organisms to adapt to higher cell concentrations? Or for example, there was a great paper, it was like why there are no insects in the sea I think is the title of the paper or something like that. It's a very fun paper because it's very speculative because there is no much information about it or at least there was no much information at the moment that the paper was published.

Miguel Cañedo-Argüelles:

Yeah, for example, when I became interested on freshwater salinization, it was because I was studying coastal lagoons and estuaries. All the time I was looking at an environment that was very subjected to habitat modification and many different things. When I was running my analysis, in the end I always found that salinity was the prime driver of biodiversity in my system. That was because salinity in the estuarine environments, in the coastal lagoons is draining a lot because you have the freshwater inputs from the rivers and the sea water. The violence between both of them creates unique salinity gradients. When I read about it, all the others were confirming that credit organisms usually are restricted to very narrow ranges of salinity because of the energy demand.

Eric Moody:

You mentioned that in freshwater invertebrates, for example, when salinity increases above this threshold, it becomes toxic to them. What kind of ecological impacts do you find in streams that have become highly salinized?

Miguel Cañedo-Argüelles:

The most obvious impact that has been acknowledged in a lot of different studies, is a reduction in diversity and a reduction in the abundance of most aquatic organisms. Then this depends a lot of the kind of organisms that we're talking about. For example, amphibians are really sensitive to salt pollution, to increased salinity. In the aquatic insects you might have, for example, Plecoptarans-

Eric Moody:

Stoneflies.

Miguel Cañedo-Argüelles:

... mayflies, they can be very, very sensitive. Whereas some crustaceans like Gammarus or these kind of aquatic organisms can be very tolerant. There is a wide range of tolerances to these salinity, but what's the final impact on the ecosystem functioning? That's what we're trying to answer now, more and more studies are looking into that, but it's not easy.

Miguel Cañedo-Argüelles:

For example, one thing that we've looked at and it's very straightforward and very easy to look at is leaf composition. What we find is that with increased salinity literally the composition grade is decreasing because many of the organisms that are responsible for this, decomposition are salt sensitive.

Miguel Cañedo-Argüelles:

Then we have to look at some little effects. Like for example, I recently did that study where I looked at the nets that were built by Hydropsyche, you know about Trichoptera. They build these nets to capture food particles from the water and these nets are really symmetric, they are beautiful. When we increased salinity it was like these organisms were dizzy or something. These nets were not as symmetrical anymore. They were more and more disorganized so that could have an impact on the ability of these organisms to capture food particles and their ability to feed. That can have an impact on the organic matter processing of the stream, but there is not much information in that.

Miguel Cañedo-Argüelles:

I like one paper about natural saline streams. That's something also important to know that there is a lot of streams that might be saline, they might have a lot of salts. These salts come naturally because of the geology and those streams can be very important and they need to be preserved. We need to distinguish between both, but in any case they were comparing this naturally saline streams with the streams with low salinity, like reference streams.

Miguel Cañedo-Argüelles:

In the saline streams what you find is that there is not much riparian vegetation because the trees, when you have a lot of salts they tend to die. They don't like these waters, so you have less canopy cover and when you have more light you have more primary protection. You have more algae and then you change from a heterotrophic ecosystem to an autotrophic ecosystem. They impact and the ecosystem functioning can be very high, but we don't have much data on it. You can also have great impact on the biochemical cycles.

Miguel Cañedo-Argüelles:

For example, there is a great paper of the salinization of wetlands in the US, by I think it's Ellen Herbert published it last year. They were looking at all the implications for nitrogen, phosphorus cycles and they were amazing. I mean they reported so many implications and that they impact on the biochemistry can be really high.

Miguel Cañedo-Argüelles:

As ecologists we cannot work on everything, so we usually focus on something and we study that very deeply. In the end there is a connection among all different stressors and of course salinization is occurring at the same time as many other things. We need to look for interactions between salinization and other kind of environmental stressors.

Eric Moody:

You and your colleagues have demonstrated numerous impacts of salinization on freshwater ecosystems that are sort of similar to the effects that we see from things that we more think of traditionally as pollutants, various chemicals that are released into the water. Are there any regulations on solidity similar to how we regulate other pollutants?

Miguel Cañedo-Argüelles:

Yeah, this is something that we addressed in our science paper. As far as I know, in the US there are recommendations for and legally enforces standards for salinity and there are recommendations for chloride. The US is doing probably much better than other parts of the world, where there are no even recommendations for salinity.

Miguel Cañedo-Argüelles:

I would say that in Australia, in the US, in Canada, in Europe, at least salinity is taken into account and is regulated somehow. Then when you get into specific ions and that's more difficult. Like for example, chloride tends to be regulated in some places, but you find no regulations for other ions, sulfate, potassium and so on. I saw a nice document proposing recommendations for sulfate concentrations coming from Canada administration.

Miguel Cañedo-Argüelles:

There is more and more work in this direction, but it's difficult because since sometime ago I don't think that salinization was really acknowledged by water managers or policy makers as a real environmental issue. Now I think that it's more or less, it's being acknowledged now. Everyone more or less agrees that this is an environmental issue that we need to take care of. I would say that now the next step is to produce ecologically meaningful standards based on different things. Not only toxicity tests and also have standards for specific ions, not only for total dissolved solids or for total salinity, but standards for its of the major ions that we find in our rivers and streams.

Miguel Cañedo-Argüelles:

We need to move towards a global view on this issue. Still much of the information we have comes from the US, Europe, Australia, but I know that there are huge salinity issues in Asia, in Africa. For example, in Bangladesh there are millions of people that are being displaced from the coastal areas because the coastal freshwaters are being salinized. The sea water is advancing towards the land because of over exploitation of the ground waters. This is a huge issue and it has also human health implications that we don't know about.

Miguel Cañedo-Argüelles:

I would say that we need to move towards a more global perspective, but we need to also to have a, interdisciplinary perspective. It would be great if we could couple the economic impacts of salinization with the human health implications with the ecological implications.

Eric Moody:

Is there any way to reduce the impacts of salinization on waters or to prevent salts from entering freshwaters?

Miguel Cañedo-Argüelles:

Of course, it depends a lot on the activity that you're talking about, but it's not easy. It's not easy at all. For example, when we talk about mining, I'm quite interested in mining because we have huge potash mining issues here in Catalonia. It's something that is quite important in Europe, but I know that it's also in the US. In Canada, I think that they have big potash mines.

Miguel Cañedo-Argüelles:

What is happening here is that, it's something that you can see very easily. Like when you're driving here in the road, suddenly you see a huge mountain, a wide mountain that is higher than the natural mountain surrounding it. It's basically made out of sodium chloride and that comes from the potash mines. These potash mines they are interested in potassium, but sodium chloride is not that interesting, so they stock pile it there. That's exposed to weathering again, and so what do you do with that? They've been piling this sodium chloride for decades.

Miguel Cañedo-Argüelles:

The first thing that they thought of was to build a collector. It's like a pipe surrounding this mountain and it's collecting all the leachates and then transporting them for more than 30 kilometers into the sea. That was a lot of money invested into that and the problem is that you have corrosion of the pipes with the acid that goes by so there is a lot of leaks. There are a lot of leaks and at the same time you are collecting just a part of these salts, most of the salts are still entering ground waters because this is very difficult technically to do this using pipes and collectors.

Miguel Cañedo-Argüelles:

When you talk about agriculture for example, that might be easier because in the end it's a lot about, how much water are you using? When you have salts in the agricultural fields, many times it's because you are using more water than the crops can absorb. Then there is like this excess water on the surface that is evaporated and the salts are left behind. Then salts build up in the soil and finally they go into rivers. If you were to irrigate in a more efficient way, you would probably save a lot of water. I think that's something that has been done in the Colorado River. They had like an irrigation scheme to improve the efficiency of the irrigation systems.

Eric Moody:

I want to ask you something that's a little different, but you've done a lot of work on freshwater invertebrates. In particular, you've recently published a few papers about chironomid midges larvae, which too many freshwater taxonomists are very frustrating because they all look the same and there's lots of them.

Miguel Cañedo-Argüelles:

Yeah, I know.

Eric Moody:

I was wondering how you got interested in that group particularly and why you think that they're important.

Miguel Cañedo-Argüelles:

Well, I love this question, thank you. Well, first of all, I have to acknowledge Narcis Prat and Maria Rieradevall. Maria Rieradevall was my supervisor during my PhD and Narcis Prat is her husband, and he leads the Freshwater Ecology and Management Research group at the University of Barcelona is where I'm working now and where I did my PhD too. They love chironomids. I don't know how Narcis got interested in that, but he really loves chironomids and he's one of the top experts in the world. All of their students had to learn chironomid taxonomy, and it was like a pain in the ass in the beginning for everyone. Like, "Oh no, oh my God," because they are so small and you know it takes a lot of time. You have to cut their heads and then mount it in the microscope and in the beginning they all look the same to you.

Miguel Cañedo-Argüelles:

Then you begin to love them, it's amazing how beautiful they can be and how different they are. It's not only that they are different morphologically, but they can show a wide range of ecological traits. Different food preferences and even different life cycles and different tolerance to environmental gradients. The good thing is that they are everywhere. They are everywhere, any kind of ecosystem, any kind of conditions you will find chironomids. If you build a new lake, if you restore a river, the first to arrive will probably be chironomids, so they are everywhere and they can be really useful. I even developed an index of water quality just based on chironomids and it was working really nice. Then we found that they were really cool. We were getting a lot of information out of chironomids that was complementing information that we were given by the rest of invertebrates.

Miguel Cañedo-Argüelles:

I mean, it takes a lot of time to learn how to identify these guys, but I think it's worth it.

Eric Moody:

Thanks a lot for talking with us about reverse salinization.

Miguel Cañedo-Argüelles:

Yeah. Thank you.

Eric Moody:

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