INTERVIEW WITH THE EDITORS

Limnology and Oceanography Letters Special Issue on Salinization of Freshwater Ecosystems

Elisabeth Berger, and Clara Mendoza-Lera

As awareness about the impact of salinization in freshwater ecosystems and coastal areas grows, many questions arise, urging the scientific community to better understand the impacts of salinization worldwide (Melles et al. 2023). In response to this demand, Stephanie Melles (SM), Associate Professor at Toronto Metropolitan University, Miguel Cañedo-Argüelles (MCA), a Ramón y Cajal Fellow at the Institute of Environmental Assessment and Water Research (Spain), and Alison Derry (AD), Associate Professor at the Université du Québec à Montréal (Canada) have edited a Special Issue in *Limnology and Oceanography Letters* (Salinization of Freshwater ecosystems). In January 2023, we sat online with them to learn more about salinization and the main findings of the Special Issue.

Interviewer (I): Welcome. How did you personally first become aware of freshwater salinization?

AD: I am from Quebec and we have long winters. So, the application of road salt here is very obvious. But it is through the scientific literature that I became aware of the global scale of the problem! I first started working on naturally saline systems as a graduate student in Western Canada, and I observed how different the biological communities in those are compared to freshwater systems and how species-poor they are even though life evolved in that environment! Together, this shows that salinization could really be having an impact on an enormous scale.

MCA: For me, it was because of the salt mines in Catalonia (Spain). Potash is extracted for fertilizers, but some components like the sodium chloride are not very profitable and it has been stockpiled for more than 50 years, forming a huge white mountain that dominates the landscape and I wondered: "What happens with this salt?"

I: How did you then meet and conceive this Special Issue?

AD and SM: At a Global Lake Ecological Observatory Network (GLEON) meeting—GLEON is an amazing network that brings together like minded researchers—the idea of a coordinated mesocosm experiment in lakes using a standard methodology across huge regions was conceived. In the past, most studies on the impact of salinization on biota, and zooplankton in particular, were done in the laboratory and very few were performed under realistic natural conditions with even fewer across broad spatial scales. The group was led by Shelly Arnott at Queen's University and Bill Hintz from University of Toledo and they mobilized their networks to get people to do this amazing experiment. It was a 6-week experiment, which sounds easy, but was quite intense!

MCA: Yes, it was a big collective effort. The experiment was completed in 16 separate lakes, so we are talking about 16 labs, each lab involving maybe 4–6 people. It is very exciting to now see it all that coming together in the Special Issue.

SM: We have a great database because of it right now. We got together at Queen's University to work on writing a Proceedings of the National Academy of Sciences (PNAS) paper about the outcome of the experiment (Hintz et al. 2022), and we realized there were so many more papers that we needed and wanted to write. People were going off into their separate directions, so we really felt the need to put a Special Issue together. Since I was on a sabbatical that year I knew I would have the extra time to take the lead and it worked out.

AD: Once the announcement of the Special Issue was circulated to the broader scientific community in aquatic sciences many other contributors joined. There was a lot of broad interest.

I: What are for you the most surprising findings from the coordinated mesocosm experiment, but also from the additional contributors to this Special Issue?

SM: The main finding across mesocosms was a 50% decline in zooplankton abundance, which also led to shifts in the communities, increases in algal communities, and a decrease in overall diversity (Hébert et al. 2023). Arnott et al. (2023) looked at intraspecific variation and found that the same species will have a different response to salt between lakes. We wanted to explain and predict that variation using environmental factors, but it was not explained by anything other than the community itself. This was a big surprise, because we thought the spatial location, the variability in the environment, and maybe past history would have an impact on how an individual species responds to salinity.

MCA: Yes! This means that species interactions are modulating toxicity. There's another paper in the Special Issue from Ben Kefford (Kefford et al. 2023) showing that results differ whether you use a single species laboratory toxicity test or taking the whole community into account. This is very interesting from a regulation point of view, since it questions how the standards for chloride or any other substance in the environment are established, which is done without accounting for the complexity of ecosystems and species interactions.

AD: Our water quality guidelines are way too high in Europe and North America because they are all based on laboratory toxicology studies. One of the real take-home messages for policy is that we really need to change what we're doing. Using an environmental DNA metabarcoding approach, we saw that the whole eukaryotic planktonic community, from phytoplankton to fungi to protozoans to zooplankton, shifted at a very low level of salt below the Canadian water quality guideline that is even lower than the US guideline (Astorg et al. 2023).

SM: There were also couple of studies that looked at interactive effects, like salt plus nutrients or temperature. Surprisingly zooplankton responded to salt but not so much to temperature, while phytoplankton was more affected by temperature. We need more studies to understand those kinds of interactions. What we also really need is to do the hard work of thinking about how we can change our regulations and our behaviors to reduce the salt loadings going into our natural ecosystems.

I: Is there a specific readership you're targeting with the Special Issue, such as policy makers?

MCA: I think, the first step is to make salinization visible within the scientific community. We need to provide more evidence on its urgency.

I: Is salinity something that ecotoxicologists don't consider as it is "natural" nor ecologists because it is "normal"?

MCA: Yes, that's one of the key points. In freshwater science electrical conductivity and salinity are measured to characterize background conditions like the effect of geology, but they are not seen as potential stressors.

SM: In the Great Lakes, for example, the water cycle eventually washes everything down into the ocean and the ocean is extremely salty. So, I've had colleagues say, "Why worry about it? It's just going to get washed out into the sea eventually anyway." Even in North America, although it is such a huge issue, we will see people not thinking it's that critical because salt is so natural. However, the paper from Dugan et al. (2023) shows that over 1 million metric tons of salt go into Lake Michigan alone per year. If we continue on this trajectory the levels of salinity could be over 18 ppm by 2050. Historically, it would have been around 2–3 ppm.

I: Would you encourage more people to research salinization and how do you see it related to other problems?

MCA: For me maybe the most urgent is to understand the wider picture. That is looking at ecosystem functioning, biodiversity, ecosystem services, and human welfare related to salinization all together. And here I am thinking particularly of understudied regions like Africa, Asia, and South America, where even if the water is salty people drink and use it anyway, so it becomes a health issue as it has been shown to be in coastal Bangladesh. I recently learned that the Amazon River has received thousands of liters of hypersaline water, four times higher than ocean water, on a daily basis for years from the oil industry. And we know virtually nothing about that!

AD: I think the invasive species angle is pretty interesting and very understudied as well. In the St Lawrence River in Montreal the distribution of invasive species is strongly controlled by conductivity and salinity. This is an interaction that will probably become more emergent in terms of us trying to get a handle on the effects of salinity beyond the direct toxicological effects.

SM: Yes, salinity is such an understated issue with so many causes and a really big impact, similar to the impact of change in temperature related to climate change, but we don't think of it that way. So, I think, definitely the research needs to continue and especially from an integrated research perspective. We need to integrate across fields; policy, social sciences, and more hard sciences, physics, engineering, and ecology, and to get a fuller picture from various regions around the world. It's a complex syndrome, so we need to approach it from different perspectives.

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Elisabeth Berger, RPTU, Institute for Environmental Sciences, Landau, Rheinland-Pfalz, Germany; berger@uni-landau.de

Clara Mendoza-Lera, RPTU, Institute for Environmental Sciences, Landau, Rheinland-Pfalz, Germany