CHALLENGES FACING PESTICIDE ANALYSIS AND MONITORING

AN INTERVIEW WITH DR. SIMONE HASENBEIN

Rachael Simpson. Editor of IET.

Q: Lovely to speak to you again Simone. You're working on pesticides at the moment, looking at the effect of pesticides and insecticides in water, so for the readers of IET would you be able to give an overview of the most common techniques and methods for pesticide analysis available at the moment?

A: In pesticide monitoring there are a few different ways of monitoring pesticide concentrations. The first one is to go out at certain time points to monitor and take water samples from different watersheds throughout the season, and then analyse those samples on the instruments you have available. Another one is biomonitoring, where you determine the invertebrate community in lakes and rivers for example, and use them to determine not only the water quality but also the ecosystem health. There are all sorts of bio-indicator species as well as different sorts of monitoring programmes that have been developed in the US and also in Europe where a species that is collected matches certain water quality standards. Some species, like mayflies for example, are indicators of a cleaner watershed, and then there are other species that are more common in not-so-clean watersheds. This gives us an idea of how healthy the ecosystem is.

Other possibilities include so-called in-situ exposures, where organisms can be exposed to contaminants in cages or tanks, for a certain period of time. For example, here in the Bay Delta system near San Francisco we've got a study where we expose organisms during a storm event and then look at survival and also sub-lethal effects after storm events where we expect lots of pesticide runoff from adjacent agricultural fields. This gives us an idea of how toxic these concentrations of pesticides are on the organism we are interested in.

Another method is to take water samples into the lab and then expose lab organisms to those water samples. The reason why it's really nice in my opinion to work with organisms like this is that in recent years we have found that pesticide concentrations aren't, luckily, that toxic any more, they often don't kill organisms, so these organisms give us a better idea of how they are affected – we can look at sub-lethal endpoints, such as growth or their behaviour over certain periods of time and see how those concentrations [of pesticides] affect them in the longer term even though they don't kill them.

There are a lot of ways to monitor pesticide concentrations in our watersheds and I'm happy to see that people are using a good range of methods. I'm sure there are lots of other techniques that people are using too that perhaps I haven't mentioned, but the ones I have are the most common ones to my knowledge.

Q: In terms of improving these methods, is it possible do you think to make them faster, more efficient, cheaper or more readily accessible to researchers?

I would say there is definitely a need to improve current methods, and to make them faster – all these monitoring methods take a really long time! I am impressed by all the monitoring improvements, and there are just so many people involved in these efforts and of course lots of funding too. It's really crucial to develop and work on methods to facilitate our monitoring efforts which will in turn protect our watersheds and also our drinking water supplies and so on. Of course, we are also generating a lot of data in these efforts so one possibility for improvement is to bring data modelling in. I know that there are lots of groups that are working on improving modelling to make it more applicable to what is actually going on in the world, and since monitoring efforts produce so much data, they should be used in modelling to understand the whole picture.

Another thing close to my heart is the issue of pesticide mixtures. Because of my research we have seen that the mixtures the organisms are exposed to are more toxic than the individual compounds. As discussed in our previous interview, usually in pesticide risk assessment people only look at a single compound, but actually mixtures are really crucial to look at as they have a huge impact on the organisms.

There is also huge potential for collaborative efforts. People need to put their heads together and combine forces – there are lots of groups, private organisations, public organisations and us researchers, but we are all caught up in our own little worlds. There is so much room to improve those collaborative efforts, to be more effective and also more cost effective.

Another long term goal that I see is improving the detection limits of analytical methods. Chemists are doing great work on improving instruments and there are great companies out there that are working hard on lowering detection limits so that we can actually detect the concentrations that are causing negative effects on the organisms that we see in biological monitoring, for example. Sub-lethal endpoints are more and more important to be implemented in regular monitoring efforts. Based on the research that I've been doing there are effects on growth or swimming behaviour or even gene response level from concentrations that are below the current detection limits - Bifenthrin for example at 0.05 nanograms per litre - these are really low concentrations, just a teeny tiny drop in a huge water body, but it still affects the organisms on some level. A combined effort to lower detection limits and then implement sub-lethal endpoints in regular monitoring efforts I think will be a great first step to improving analytical methods.

What we are working on here is basically improving those methods to detect sub-lethal endpoints. We are working on developing so called high-throughput methods where we can quickly monitor organisms that are exposed to a certain pesticide or ambient water samples that we are bringing in from the field, and then videotape them over 24 hours, longer even, and then look at their behaviour and how it changes over time; see if they recover from paralysis due to neurotoxic pesticide exposure, or if they are just fine, for example.

Another thing I am working on, just as a little side project, is science communication. What we can do as researchers to involve the public with outreach and education. I think it's really important as scientists that we really convey our message very clearly, explain what we're doing and what the issue is and involve the public even in our monitoring efforts. There are new volunteer programmes with the US EPA, and I'm sure this is true for Europe too, where they involve volunteers in biomonitoring efforts. So people can just go out and identify insects in the lake in their neighbourhood for example, generating data that researchers and agencies can then use.. Of course, it's not all standardised, which is really difficult to implement because monitoring groups cannot be everywhere at the same time. Having these community programmes in place, however,is a really great way to not only involve the public in generating this data but also to make them aware of what's going on in our watersheds and the world in general.

Q: Are you finding in your work that your work is limited in any way by the techniques currently available, and if so, how?

As researchers, if a method is not available we will just develop one, but for traditional monitoring there are definitely limits due to all the sub-lethal end-points that I am talking about. Because we are developing them ourselves they are not necessarily available for an agency that is conducting monitoring so we are trying to work on making those tools and methods more accessible and easy to use so these agencies don't have to pour a lot of funding into new methods. Money is becoming really restricted everywhere and so we are trying to come up with a method that can easily be applied which is cheaper and faster for everyone. There is still a long way to go I am sure, but hopefully this would be something they could apply.

I think sub-lethal endpoints are the way to go right now and they will get more and more important as the pesticide environment changes. There are so many pesticides released every single day and monitoring programmes just cannot keep up with them, or even analytical chemists developing all those methods to detect

all those different pesticides, as there are just so many. This is a broad research goal for us, to make those methods more accessible for your everyday analysis.

Q: Going back to what you about the need for more collaboration, why is it difficult to arrange these joint research efforts?

That's a tough question and I wish I had a really easy answer! I know there have been lots of people trying to bring other scientists and researchers together. I guess one thing could be that we are all so caught up in deadlines? Using myself as an example, I'm a post-doc, I'm trying to publish and just got lots of deadlines, I'm trying to get lots of things done, so sitting down and working out a schedule with other researchers is just one more thing I'd have to do. I'm sure this is true for everyone else too, we are just all so busy, but I guess it could be made easier.

I'm sure if there was funding available specifically for these kind of efforts where people come together and work on a project as a team, that would improve collaboration in the future. It would be really helpful – it would be fantastic.

Q: So do you think that the crowdsourced research you mentioned earlier could fill a void whilst these collaborations remain difficult to arrange?

I think that involving the public is a very powerful tool. Laws get changed because of the public, because of what they need and what they want for the environment, and getting the public on board looking at the watersheds nearby is a no-brainer in my opinion. That would be so easy, having them all on board and working together for the same goal and making them care about the watersheds agencies are trying to save and conserve. Once the public gets involved there is just so much work that can get done. I think it's a really powerful tool and a good way to generate data. Again, I know it's not standardised but there are programmes that provide identification keys to the public which can be used to identify organisms. It's not your "top" science obviously, but it's still very valuable information. As I said earlier, monitoring is just such very hard work, so having a few more pairs of hands to help would be great, I'm sure.

Q: We spoke a few months ago about the work you're doing looking at the sub-lethal effects of pesticides on organisms in watercourses – have there been any new developments in this work?

In the past I was looking at the effects of pesticides only, but in the light of climate change you cannot ignore the fact that certain environmental parameters will change in the future. No matter where we are in the world the temperature will change, and salinity will change in certain watersheds due to more ocean waters coming into watersheds – that's what is happening currently in California because we don't have enough rain or melting snow packs – so there is a pressing need for us toxicologists to also look at multiple stressors, not just contaminants as individual stressors. I am therefore currently working on bringing many of these stressors together and looking at the effects on organisms that I am interested in, and hopefully from that I can draw conclusions for that particular watershed and what this means for the future. So I'm mainly analysing data at the moment, and I will have more information soon, but it seems very promising right now.

Q: So are you expecting to see a combined effect of climate change and pesticides that would be greater than the sum of each on their own?

Yes, that is what we are expecting. Based on the research that we have done, and from data that has been published from other groups, either on climate change without an exposure to contaminants or an exposure to a contaminant at different temperatures. We know that some pesticides are more toxic the higher the temperature such as organophosphates for example. Pyrethroids get more toxic the cooler it gets. We won't only be experiencing hotter temperatures in the future but also colder ones and we have to take into account both of these changes.

We are definitely expecting different toxicities in combination with environmental stressors such as changes in salinity or temperature. In my preliminary results we have found that different salinity affects toxicity - I haven't even taken temperature into account in the exposure that I recently did, but even a small increase in salinity changes the organism's response. Without any salinity, in freshwater, we saw that the organisms were fine, but with increased salinity we could see a decrease in their swimming behaviour and even in their survival which is very worrisome in my opinion, I think therefore that there is a pressing need in the future to combine those stressors because of these findings.

Q: It sounds very interesting. Climate change is still such an unknown quantity in some respects still but if your work can show that in certain areas where the climate is changing that we need to back away from the use of certain pesticides and insecticides that is a hugely important thing.

It is, I couldn't agree more. And unfortunately ecotoxicology is mainly focussed just on the effect of contaminants and doesn't take into account the other factors, and ecologists and climate change experts don't necessarily take into account the contaminants as a factor – it just depends on their own perspective I guess – and so there is now a push in research to combine those two sectors. I think this will hopefully give us some really good ideas on how to avoid the sixth mass extinction event.

Simone Hasenbein

Simone Hasenbein, Ph.D. Postdoctoral Scholar, School of Veterinary Medicine, Dept. of Anatomy, Physiology and Cell Biology, University of California, 1089 Veterinary Medicine Drive, Davis, CA 95616, USA • Tel: +1 (530) 752-3141 • Email: shasenbein@ucdavis.edu • Twitter: @simonehasenbein • **Web: https://simonehasenbein.com/**