Can Microplastics Spread Killer Bacteria?

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SPEAKERS

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Maggie Fox 00:01

Hello and welcome to One World, One Health, where we chat with people working to solve the biggest problems facing our world. I am Maggie Fox. This podcast is brought to you by the One Health Trust with bite-sized insights into ways to help address challenges, such as infectious diseases, climate change, and pollution. We take a One Health approach that recognizes that we are all in this together and everything on this planet — the animals, plants, and people, and the climate and environment — are all linked.

We're going to connect two problems in this episode: microplastics and antimicrobial resistance (AMR). This is not an intuitive link, and we'd like to explore how scientific research can help answer questions that people might not even have thought to ask.

Microplastics are little pieces of plastic that are seemingly found everywhere, from the top of Mount Everest to deep inside our bodies. Most of all, they float around in water, in oceans, lakes, and water treatment discharges. They are formed when plastic objects break down, and it seems they can carry pollutants such as heavy metals and drug-resistant microbes. It's this last quality we're looking at in this episode.

Neila Gross is studying for her PhD in materials science engineering at Boston University. She and her colleagues found that drug-resistant microbes, sometimes called superbugs, can grow especially well on microplastics. Could that help these superbugs spread more widely? We're chatting with her today about what her team found.

Neila, thanks so much for joining us.

Neila Gross 01:36
Thank you so much for having me.

Maggie Fox 01:41
Can you first tell us what even got you interested in doing this kind of study in the first place?

Neila Gross 01:46
Yeah, so I work in a lab at Boston University that looks at drivers of antimicrobial resistance from the environment, and we do this through the lens of vulnerable people. One of the aspects that we were interested in was waste disposal, and there's a huge topic coming up of microplastics, so we were very interested in looking to see if there was a link there.

Maggie Fox 02:09
What did you find in the study that you did?

Neila Gross 02:11
So, we first wanted to look at different characteristics of microplastics, right?

There are different sizes and shapes, and even between plastic composition and what we found was when we exposed *Escherichia coli (E.coli*), which is a bacterium that is regularly found all over the world, and to these microplastics, they developed resistance through an increased minimum inhibitory concentration.

So, when you give antibiotics to bacteria, and they're supposed to kill them, depending on the concentration of antibiotic you give, if that concentration increases, then you're seeing resistance growth. We saw that the amount of antibiotic we had to give to kill off the bacteria for 10 days increased a lot, and this was regardless of the concentration or size of the microplastics that we tested.

Maggie Fox 03:06
Can you tell us a little bit about the microplastics that you tested? How big are they? Where did you get them?

Neila Gross 03:11
Yeah, so we bought them from another lab that makes them. But the definition of microplastics is vague. It's any plastic that's below five millimetres in size, which you can see is about the size of your pinkie nail. So, we tested from 10 micrometres, which is very, very small, to about half a millimetre. And we looked at polystyrene, which is like your packing peanuts. We looked at polyethylene, which is the plastic that you find in normal water bottles, and polypropylene, which is the plastic that is found in shipping crates.

Maggie Fox 03:49
So, this is the lab you bought them from. Did they collect these from the environment? Does this kind of resemble real-life microplastics that might be around?

Neila Gross 03:56
So, the lab must make them, but they make them out of samples that they get from industry. So, it's pure polystyrene that they fabricate into smaller particles that are all the same size or all the same shape. We use steers in this study. So, we needed to make sure that we could do quality control. So, they're pure, like it was pure polystyrene or pure polyethylene.

Maggie Fox 04:20
So, what your study showed was that not only did the bacteria grow well when the microplastics were mixed with them, but they also developed this resistance to antibiotics more quickly.

Neila Gross 04:33
Yeah, so it was really interesting to see just how quickly they gained resistance, and the fact that the bacteria were resistant to multiple antibiotics, or at least all the antibiotics that we tested. We tested four different families of antibiotics. So, not only were they very quick in gaining resistance, but the resistance itself was very strong, per se. We looked at that through the lens of a clinical breakpoint, which is basically when you're using an antibiotic in the clinic in a human setting, and the antibiotic is no longer useful past a certain concentration, so you go to a different family of antibiotic, or you use a stronger antibiotic within the same family.

Maggie Fox 05:16
Okay, what might cause this phenomenon? What on earth is it about microplastics that would make the bacteria not only grow but also grow resistant to antibiotics?

Neila Gross 05:27
That's a really good question. What we found was that, basically, bacteria grow on the surface of the microplastic, and so they grow into what's called a biofilm. I always like to relate a biofilm to a house.

So, bacteria build a little house called a biofilm, and it protects them from all sorts of things, just like a house, it protects them from weather or whatnot. In this case, the biofilm protects the bacteria from antibiotics. So, when they grow this biofilm on the surface of the microplastics. They're able to resist pretty much any antibiotic that comes at them. But what we wanted to see was, "Is this the case?" Were they just microplastics, or is it any surface, right?

So, we included glass in our study, and there are lots of small glass particles from the makeup industry and textile industry, so we know that those are also in the environment. What we found was, when we looked at the surface of the glass, compared to microplastics, the glass had almost no growth on the surface, and it had less of an ability to resist the antibiotics, so it wasn't resistant to multiple antibiotics.

Maggie Fox 06:43
So, you found that this happened. Are you looking at what the mechanism might be? What is it that's different about microplastics that makes them more conducive to this?

Neila Gross 06:53
Yeah, so microplastics, or plastics just in general, have a lot of really interesting properties. I mean, they're superhydrophobic, which means they hate water, and so they sort of form this little tiny air pocket around them. We are currently looking into mechanisms, but there has been some research that has shown that microplastics just absorb antibiotics.

So, you can think of that as if the microplastics themselves are just taking the antibiotics out of the solution, right? And they're putting it into the center of the plastic themselves, and so that takes the antibiotics out of the equation, and so then it can't interact with the bacteria. But there are a lot of working theories right now that we're testing in the lab.

Maggie Fox 07:36
So, this was a lab experiment. You weren't going out and finding microplastics that were in the ocean and testing them. You did it in the lab, and there's a reason for that.

Neila Gross 07:47
Yes, so it was a lab experiment, and we did it in the lab first because we wanted a controlled environment. We wanted to see if we could control all of the variables, such as temperature and sun exposure, and all of these things that could potentially make it different.

We wanted to see just what the base interactions were, and then from there, once we understand what happens when just microplastics and just bacteria with all these controlled settings, what happens there.

So now that we have that information, we can start to tune things to make it more real-world-like and are you going to do that? Yes! So, we have several field sites that we are going to start sampling from, and we plan on characterizing what we call the "resistome." So, the resistome includes antibiotic-resistant genes. It will include different minimum inhibitory concentrations that may be due to different antibiotics. We're also interested in characterizing any microbial communities we find on the surface of these microplastics.

Maggie Fox 08:51
So, you see from these microplastics, how can these little bitty pieces of plastic, maybe carrying these drug-resistant bacteria, be a threat to people?

Neila Gross 09:00
I think it's multifold within the plastics themselves. Of course, you worry about dissemination. So, if you have antibiotic-resistant bacteria that are upstream of a town or settlement or whatnot, microplastics can carry those bacteria faster and probably better than bacteria would be able to move on their own.

So that's one concern regarding the ability of microplastics to disseminate resistant microbes. The other thing is, that we have a runway where we are running out of time as more resistant bacteria start popping up, and our pipeline for antibiotics is not keeping up with the rate at which those bacteria are becoming resistant, so identifying key drivers, like microplastics, for instance, of antimicrobial resistance might allow us to extend that runway that. We have to find more novel antibiotics or different solutions to antimicrobial resistance because that allows us to plan and potentially create some mitigation strategies.

Maggie Fox 10:12
Is there any evidence out there now that microplastics are spreading drug-resistant bacteria?

Neila Gross 10:17
There are some correlations, I wouldn't say that there are any causation studies that have been found, but we do know there was a recent study that was just published that found within soil samples, microplastics increase the rate of horizontal gene transfer, which is just the bacteria's ability to give genes to other bacteria, and those might be resistant genes and what not.

Maggie Fox 10:42
That's an interesting quality of bacteria, right? They can swap these whole cassettes of drug-resistant genes with one another. They can just, like, show up, and it's like, "Here, have some drugs." You know? It's the equivalent, right, of somebody dealing drugs. They can just spread this resistance to other bacteria.

Neila Gross 10:57
Yeah! I know it is. I think in biofilms, particularly, you see a huge increase in that rate of swapping. So, if you find that microplastics are increasing biofilm formation, then you know that not only does that provide a sort of armor for bacteria, but it also allows bacteria to talk to each other a lot easier, and so that rate of horizontal gene transfer increases, you know, hundreds of folds.

Maggie Fox 11:29
If there's a piece of plastic and it's got this biofilm growing on it, what's the likelihood that these bacteria will get out, or their genes will get out, or their resistance will get out? Because, as you said, it's like having a little house and they're hiding in this little map that they have built. So, are they very secure with these microplastics, and perhaps not a danger?

Neila Gross 11:51
Yeah. So that's a great question, and it's a unique feature of biofilms. Biofilms have a lifespan where they are grown, and then they're sort of kept by the bacteria that are living inside them. So those bacteria use the biofilm and sort of do upkeep on it.

But then after a certain number of days, the biofilm will disperse, and so It'll kick out a lot of the bacteria that are living in there, which is, as you can imagine, a problem because if you have all of these bacteria that are inside swapping genes and becoming more resistant, and then the biofilm releases them into the environment, it's just another mode for them to gain more resistance.

Maggie Fox 12:37
Neila, your lab also focuses on vulnerable people. Was there a specific link that you were looking at when you were looking at microplastics?

Neila Gross 12:46
So, the research that's come out showed the plastic load that we have within our bodies, those are done on people from Europe. You can imagine someone who lives in a place that doesn't have waste disposal. So, imagine just living around your trash, or a lot of people in low-income countries burn their trash. So, imagine sitting next to a fire where you're burning all of the plastic. And plastic does not go away, right? It just goes into smaller pieces, and so you're inhaling all of that.

So, you can imagine that the plastic load that we have that's come out in recent studies is probably, I don't know, a 10th of the plastic load to those who don't have adequate waste disposal, and that's just a random guess.

I mean, I'm sure it probably is more, considering how ubiquitous these plastics are everywhere, and so I have lived in several countries in East Africa, and I can say that one of how we got rid of our trash was just to burn it.

Maggie Fox 13:50
So, what can anybody do right now about this potential problem?

Neila Gross 13:55
There definitely are ways in which you can lower your plastic use. Lots of people have been de-plasticizing their houses, and I think that's one way, you know, decreasing plastic use would be good for the environment, definitely, and would potentially help what's going on here.

I also think, just following good antibiotic stewardship, you know, taking your antibiotics through the course, and not throwing out your antibiotics and whatnot into the environment. I think those are very good things that you could do to sort of slow down this problem, and for each of us to do our parts.

Maggie Fox 14:33
Neila, thank you so much for coming to the show and talking with us.

Neila Gross 14:37
Yeah, thank you so much for having me. I enjoyed our talk.

Maggie Fox 14:41
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