Environmental Audit Committee

HOUSE OF COMMONS

Oral evidence: Environmental impact of Microplastics, HC 925

Monday 9 May 2016

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Written evidence from witnesses:

- University of Exeter
- Grantham Institute for Climate Change
- King's College

Watch the meeting

Members present: Mary Creagh (Chair), Peter Aldous, Margaret Greenwood, Peter Heaton-Jones, Caroline Lucas, John Mc Nally, Rebecca Pow.

Questions 1 – 64

Witnesses: **Professor Tamara Galloway**, Professor of Ecotoxicology, University of Exeter, **Dr Erik van Sebille**, Faculty of Natural Sciences, the Grantham Institute for Climate Change, Imperial College, and **Professor Frank Kelly**, Professor of Environmental Health, King's College London, gave evidence.

Q1 Chair: We are beginning our first public evidence session into microbeads, marine plastic pollution, and we are delighted to be joined by three eminent witnesses today. From left to right we have Professor Tamara Galloway, Professor of Ecotoxicology from the University of Exeter; in the middle we have Professor Frank Kelly, Professor of Environmental Health and a Deputy Director of the MRC-PHE Centre for Environment and Health at King's College London; and to my right, Dr Erik van Sebille, Faculty of Natural Sciences at the Grantham Institute for Climate Change at Imperial College. I am sorry not to have gone your science festival yesterday, but I am sure it was very interesting. We are getting our own science festival here today. Thank you all for being with us, and our apologies as a Committee for the cancellation of last week's session. That was mostly due to our inability to guarantee attendance given the elections, so thank you for making the time to be with us today.

I would like to begin with an opening question about the public concern on this issue. Perhaps I can address this to you, Professor Galloway. Why do you think concern about microplastics has focused so much on microbeads in cosmetics and toiletries rather than on industrial uses or plastic bag degradation or from washing machines?

Professor Galloway: I think that in terms of public interest, this is something that people can identify with. It is more likely to be something that they are using every day and that they can see in the products that they are using.

Professor Kelly: I think the public have, over the last five years, come to understand terms like nanoparticles and nanotoxicology and they have been introduced to these terms in the media on a reasonably constant basis. When they realise that a lot of the products contain materials like microplastics, they start to wonder why they are there and then they associate that with some of the stories in the press about contamination of sewage and our marine environments and so on. I think it is a gradual accumulation of evidence and a realisation that this is another thing we are doing to our environment that we really should not be doing.

Dr van Sebille: I agree with the first of the speakers. I also think that the public might think that this is something unexpected; that plastics are part of toothpaste and exfoliants and all these cosmetic products might catch them by surprise and it might also make them think, "Why don't we have something else? Why don't we have something better for the environment, something degradable? Would it be possible to change?" It makes more sense for a lot of the other plastic products that we have around them that they are plastics, because the properties of plastics literally go into these products. For some cosmetic products, maybe it is less easy to see for the public.

Q2 Chair: We have seen evidence that suggests that microbeads make up only 0.01% to 4% of the range of total microplastics entering the environment and the other major source of microplastics is pollution from synthetic fibres, particularly fleeces, in domestic washing machines. Do you think the focus on microbeads is helpful in addressing the broader issue of marine plastic pollution?

Professor Galloway: I think it is important because I have seen some figures from PlasticsEurope that suggest that the amount of microbeads used across Europe is something like 4,500 tonnes. If you look at the estimate that about 8 million tonnes of plastic enters the marine environment every year, that is perhaps a small figure, but it is an amount that we can do something about. I think the issue is that it is a very positive thing to be able to remove without doing particular harm to the environment.

Professor Kelly: I think it is also felt that it is a relatively new way in which these products are being used, therefore it may be 4% today but in 10 years' time it may be 30%, and again—back to the original question—why do we need them in these products? Is there not something that is more appropriate?

Dr van Sebille: I agree that this is low-hanging fruit, that this is the kind of thing that we can probably very easily ban without much harm both to the products and to their use, so why not do it?

Q3 Chair: The alternative is the apricot kernel, I believe, or it was at least used in other products. Is that as harmful, less harmful? Obviously it is a natural product, but do we still want apricot kernel grains washing into the sea or is that all fine? Is it better not to have apricot kernels? A genuine question.

Professor Galloway: The sea is full of particles and most of those particles are organic in origin, and by definition they are more likely to be biodegraded. The majority of microbeads in cosmetics are made out of polyethylene and there have been some estimates from polymer scientists that in a year only 0.1% of polyethylene would be broken down to its constituents, probably slightly lower than that. So if you continued to produce polyethylene at a defined rate that is more than 0.1% of what is already there, then you are obviously going to accumulate and accumulate, whereas if you put an organic compound that was going to degrade, you would not have that accumulating effect.

Q4 Chair: So the erosion of the salt and the movement would gradually break and break and break organic things down?

Professor Galloway: Yes, and oxidation from the action of the sun and from UV light also.

Q5 Chair: How much awareness do you think there is in the industry and more widely of microplastic pollution from clothing and, in your view, which fibres cause the most pollution and where are they most used?

Professor Kelly: It is not something that I am an expert on, but my understanding is that as clothing becomes more technologically advanced and provides us with heat and coolness, but in a lighter garment, there is an increasing use of plastic products. That would be a trend I would see as continuing as we move forward, especially as we move towards more high-tech clothing. I am not sure which is the most damaging of the particles or fibres involved, but I would conclude by saying that anything that has a very low degradability index—that will be in the environment for a long period of time—would not be good.

Q6 Chair: Within the plastics hierarchy, which is the worst and which is the best at degradability, or do we not know? You can write to us instead if you want. This is not an exam.

Dr van Sebille: I think we are hesitant because degradability is not one property of the material. Degradability also very much depends on the environment the plastic is in—the amount of sunlight it sees, the temperature of the water, and it depends very much on the amount of wave action. Most of the

degrading, especially of bigger plastic particles, comes through wave action. For instance, in some parts of the ocean where wave action is much stronger, the plastic degrades faster. That gives you a whole range of degradabilities, a whole range of timescales in which this happens, which makes it very complicated. There are all kinds of things happening. Biofouling on plastic is another complication; any type of plastic gets bacteria and algae growing on it. As Professor Galloway said, there are a lot of floating things in the ocean and they seem to attract marine life, which starts growing on it. That can weigh the particle down, so that a particle that is initially buoyant slowly starts sinking. It becomes really complicated as soon as you start realising that as it sinks, bacteria eats the algae on these particles, so they become positively buoyant again, and at some point they might start rising up again. You get these cycles of sinking/up and sinking/up and all the time degradation is going on by the sun and by the waves, as I said. This is a very complicated scheme and there is not one number.

Chair: Thank for you explaining that so incredibly clearly. I feel like we are at sort of undergraduate level.

Professor Kelly: In experiments, we take these materials and put them in the chambers and expose them to UV light under different conditions, trying to replicate some of the natural ways in which these products will be degraded. That is a very difficult experiment or series of experiments to do. I think the bottom line is that we don't really have an appropriate answer for you at this point in time.

The second thing is the fibres themselves. A lot of them will contain various additional chemicals to give them additional properties and it will depend on what they have been mixed up with and what the components are on the fibres, so that will influence their degradability as well.

Professor Galloway: If you look at the top four highest-tonnage plastics that enter the environment, the one that probably degrades the most is PVC. Therefore, it is the one that contains the most additives because it is important for its production to be able to withstand the kinds of things that might break it down.

Q7 Caroline Lucas: There is a whole new range of things to worry about now. Some companies have said that they will phase out microbeads in personal care products and I think some already have. What kind of effect will that voluntary action of different companies doing that have? Do you think it is enough?

Professor Kelly: It will depend on the number of companies and the volume of products that they are releasing on to the market as to whether that is going to have any sizeable impact on the problem. If some major market products do move into that category then maybe they can use that in a positive marketing way and demonstrate to the public that they have a product that does not require these plastic components in them. It will depend on, as I said, who takes it up and who doesn't.

Professor Galloway: I think it has been estimated that for some products, each time you take a shower you might wash 100,000 particles down the sink, so every time you take a shower that does not have microbeads in it, you would have 100,000 fewer particles washing down the sink. I think most manufacturers have been very positive, because there are alternatives that can be used, and it is a very positive message to be able to stop anything that might be harming the environment that there are alternatives for.

Q8 Caroline Lucas: Are the alternatives equally cost-effective and will any of the companies say it is going to cost them more?

Professor Galloway: I could not comment on the cost of them.

Dr van Sebille: I have heard from colleagues that it might not even be a cost issue but more a shelf-life issue. One of the advantages of plastic over something biological is that it has an infinite shelf life—that you can have a product that can stay there for a very long time. The other advantage is that it is much easier to control the size of particles, it is much easier to control consistency among products and that is why some products still may contain plastics.

Q9 Caroline Lucas: I do not know whether or not apricot kernels are related to—how do you pronounce it—jojoba?

Professor Galloway: Jojoba.

Caroline Lucas: Yes. Do you know much about that being used as an alternative? I was surveying my cosmetics before I came out and this seems to be the thing that is in it.

Professor Galloway: That is an oil, isn't it? It is an oil that you would add to—

Caroline Lucas: But I think they make it into a wax. It probably doesn't matter. Essentially the significance of companies phasing this out depends on, as you say, how much they are using them and how big the companies are and so on. But broadly speaking, if you look at the personal care product area, do you think pushing for a ban at a UK level or at an EU level is the best way forward? Are you relaxed about a voluntary approach? What do you think is the best mechanism to drive these out of products?

Professor Kelly: I think it would be good. I am not sure if there is yet a sufficient level of appreciation and understanding with the public as to what is in these products, so I think there would be a requirement for a debate on the issue at a public level. If you are going to move towards a ban, you would need to help the public understand why that was needed. I would imagine a ban would have to be at an EU level as a minimum to be effective.

Dr van Sebille: I agree. It is important to realise that this is a transnational problem, that plastic in the ocean is in constant motion and it moves plastic around on the currents. Plastic that gets into the ocean from the UK might very well end up, if it is floating for long enough, on the other side of the Atlantic in the US. We might get some of our plastic from the US in return. There is a great connectedness of all the countries that border an ocean, and that extends even to countries that don't border an ocean because plastic still ends up in the ocean through the rivers. This is not something where a country can just keep itself and protect itself; this is a transnational problem.

Q10 Rebecca Pow: I wanted to pick up on looking at the cosmetic products in our cupboards. When you said 100,000 particles wash down the sink every time we have a shower, do you mean from exfoliants, not from shower gels and things like that? What are you talking about?

Professor Galloway: There are shower gels that contain microbeads as exfoliants or whatever.

Q11 Rebecca Pow: So most products, then?

Professor Galloway: Many products. Most products will say—

Rebecca Pow: Most products people are using in the shower or bath?

Professor Galloway: Yes. Most products that contain them will say so on their label somewhere. They will either say it as a positive thing, as in "with microbeads", or it will be listed in the ingredients on the back of the bottle.

Chair: There is an app you can check. There is an app for that.

Q12 Rebecca Pow: These notes say that 86,000 tonnes per annum comes from facial exfoliants—the ones that you use to rub your skin smooth and shiny and gorgeous, in case people don't know. So it is not just those; it is also shower gels—I want to make that clear—so men could be using them as much as women?

Professor Galloway: Yes.

Chair: That is helpful.

Q13 Caroline Lucas: On the microplastic pollution resulting from clothing, would we be looking at alternatives to synthetic fibres or would it be a question of trying to talk to manufacturers to make them aware of the problem and get them to close it down?

Dr van Sebille: I think that especially with fibres it is going to be very difficult, because these garments have a use and, as Professor Galloway said, they are there because they work very well. I feel that solving the fibre problem might mean engineering solutions, where it is about better filtering of wastewater treatment plants. That is another option that we have not talked about yet, where civil engineering can do something at some point about taking these fibres out in a better way.

Q14 Caroline Lucas: Is there much work going on in that area?

Dr van Sebille: People are starting up, yes. At Imperial College there is now a lot of interest from the civil engineering department in starting to think about this.

Professor Galloway: It might be worth pointing out that when we look at the samples that we are analysing in our lab that are taken from either local waters or from marine organisms, the most frequently reported item that we find are fibres.

Q15 Caroline Lucas: This more technical solution would not work for your microbeads because you would leave them down your plughole or something, or would it?

Professor Galloway: The evidence suggests that they pass through sewage treatment works under the current conditions in the sewage treatment works.

Q16 Caroline Lucas: But that wouldn't mean that some kind of water filter could not work, or does it mean that? Are fibres easier to catch? Is that the point, that they are bigger?

Dr van Sebille: There was an interesting study published a few months ago where they looked in the Chicago area, I think it was, at the amount of plastic going into rivers from sewage treatment plants. They found that out of nine or so sewage treatment plants, seven released a significant amount of microplastics, both fibres and microbeads. Two of them did not. They went on to look at why that was and it turns out that these two used sand filters and they were the only ones that did. A sand filter might work very well, but the problem is once you go into that, at some point you have to backflush your sand filter, you have to push it back, and then what do you do with that sludge? Going through the evidence provided by Professor Thompson, he also talks about that, saying that what you get is a very high concentration sludge of fibres and microplastics. Currently we have no idea of how to dispose of that in an environmentally friendly way.

Chair: Okay, so the solution has a problem. Thanks very much.

Q17 Peter Heaton-Jones: I want to just go back to look at the bigger picture, and a fairly basic question to start with: can you estimate what proportion of all the plastics washing around in the ocean could be defined as microplastics? I am going to show Devon bias, and I will start with Professor Galloway from Exeter.

Professor Galloway: It depends if you look at mass or number, because obviously larger plastic items are bigger and heavier, whereas small microbeads are much smaller. If you look at the actual numbers, then most of the items that you find in the sea are microscale, but if you look at mass and you have a milk crate, that is much heavier than a microbead. So that is a bit of a non-answer.

Q18 Peter Heaton-Jones: Would there be a danger that if you just look at the mass figures, you could be mistaken for thinking that microplastics are not such a huge problem? For instance, the briefing I have in front of me says—and I am glad that the figures are straightforward because even I can do this maths—that the total amount of plastic floating on the ocean surface is up to 236,000 metric tonnes and the estimate of the weight of microplastics is very conveniently 236,000 metric tonnes. On those figures, only 1/1,000th of all of the plastic is made up of microplastics. I do not want to put words into your mouth, but are you saying it is wrong just to look at that figure?

Professor Galloway: I think the issue is that as you break things down into smaller and smaller particles you increase the surface area. The surface area is where plastics can interact with chemicals and other things in the ocean and it is also the surface area from which things can leach out into the environment. If you were to take a plastic bag and break it down into microplastics, the plastic bag might have quite a small surface area, but if you break it down into microplastics that surface area might be increased 3,000-fold, so you are opening up the area at which reactivity could occur. One other thing to say is that microplastics overlap with the size range of food items for a lot of the creatures and animals that are at the base of the marine food web and that is the issue. It means that the plastics can be ingested.

Q19 Peter Heaton-Jones: So they are potentially far more damaging?

Professor Galloway: Potentially, yes.

Q20 Peter Heaton-Jones: Does anyone else want to add anything on that point?

Professor Kelly: If we think about the airborne particles that we worry about from vehicle exhaust, the particles that you can't see, they are microparticles or nanoparticles, and it is those particles that are causing health effects both on ourselves and across the environment in general. Anything that is plastic can become a microparticle under the right conditions, so I think we worry about both numbers.

Q21 Peter Heaton-Jones: Let me make sure I also understand what we mean by microplastic. The EU defines microplastic as less than 5 millimetres. Is that right? Is that a generally accepted definition?

Dr van Sebille: That is the definition that we all work with; yes.

Q22 Peter Heaton-Jones: But is there scientific agreement across the board that anything less than 5 millimetres is an accurate definition of a microplastic?

Professor Galloway: Some people also use the definition of less than 1 millimetre. It depends on what you want to know. It brings in a slightly larger size range and generally it depends on how you are collecting your samples—whether you are using larger nets and sifting through the surface of the ocean.

Q23 Peter Heaton-Jones: But would you recommend for the purposes of this Committee that when we talk about our inquiry into microplastics, what we should be inquiring into is 5 millimetres and less?

Professor Kelly: Yes, generally, because anything that is 5 millimetres and less can become 1 millimetre and less eventually, and so on.

Peter Heaton-Jones: Yes, very good.

Dr van Sebille: I want to say something more about degradation—the point I made that degradation is always happening and big plastics become smaller and, as we have heard, small plastics have bigger impacts. If the plastic is already small when it gets into the ocean, of course the impact happens much closer to our coastlines. If you think about the impacts that plastic can have, most marine life is near coastlines, so the plastic is most damaging when it is near coastlines. It is also most damaging when it is small, so microplastics, when they get into the ocean, are more damaging in general than larger plastics that break up as they move through the ocean.

Q24 Peter Heaton-Jones: Thank you; that is useful. May I ask a geography question, which follows very nicely from what you have just said? Is there any reason why the amount of microplastics we would find in our oceans, and in coastal areas in particular, would differ markedly geographically as we go around the coast? For instance, I am in north Devon. Would there necessarily be more microplastics in my bit of the ocean than Caroline's in Brighton, for instance? What are the factors that will determine that?

Dr van Sebille: There are a lot of factors that determine that. On a coastline scale it is very much about the wind direction, what the tide is doing, very local circulation. On a larger scale, you may have heard of the garbage patches that are out there and that the ocean is accumulating plastic in the middle of the gyre. There is a famous garbage patch, which a lot of people have talked about, in the north Pacific between Hawaii and California, where sometimes we hear that all the plastic ends up. That is not true at all because of course a lot of plastic is in other areas. The ocean currents in general on a large scale are moving the plastics into the centre of the ocean, where they do less harm maybe, but then on a small scale there is much variability.

Q25 Peter Heaton-Jones: Is there any research—is there enough research—out there that tells us where the worst areas are around the UK coast? Can anyone provide me with a figure that says how many microplastics are in the sea off Ilfracombe, just as an example? No? Okay.

Dr van Sebille: Not yet.

Q26 Peter Heaton-Jones: Would it be helpful to be able to know that?

Professor Galloway: We are working on some things along those lines at the moment, where we are comparing how much beach litter there is around the UK coast with how much microplastic we are finding in UK waters. We have not published that result yet.

Professor Kelly: Of course, source will be an important issue as well—an important determinant of that. In more populous areas there may be more release in the first place.

Q27 Margaret Greenwood: Other than cosmetics and clothing, what would be the main sources of microplastics in the ocean?

Professor Kelly: Every form of modern plastic product that we use and that is disposed of inappropriately. If you just think about your normal life, we have plastic all around us, for our food packaging and our drink packaging, and we have heard about clothes and cosmetics. It is all around us.

Q28 Margaret Greenwood: Once it is in the ocean, you have saying that it moves substantial distances. Can we identify the sources? Is there some work going on about how we can identify the sources of those plastics or is that—

Professor Kelly: I asked Erik this question.

Dr van Sebille: I am doing that. That is my research stream, I guess, so if you invite me back in a few years I will be able to do that.

Q29 Margaret Greenwood: That is fantastic. In terms of dealing with this as a problem, are we better off focusing on what is already in there and trying to deal with it or stopping these microplastics getting into the ocean in the first place? Where would you say we should focus our efforts?

Professor Galloway: I would suggest that stopping things getting to the ocean in the first place would be much easier than trying to take them out once they are already there.

Dr van Sebille: I agree with that, and also because the ocean itself has this tendency of moving plastic into the middle of the gyre and sweeping it up. Especially if you focus just on the surface, on the floating part of the plastic, which interacts much more with marine life, then the plastic that is in the ocean at this moment is moving away from the regions of highest productivity, where there is most marine life. So if you stop putting it in the ocean in the first place, that has much more impact on reducing harm and risk.

Q30 Rebecca Pow: On that note about whether we should stop the plastic getting there in the first place, it is interesting to see that 20% of all the plastic in the ocean is fishing-related, and then we discover that the microbeads that it might break down to are getting into the fish and the oysters and the lobsters. What is your view about, for example, the fishing industry needing to clean up its act? One might say it is destroying its own industry if 20% of the plastic comes from the fishing industry.

Professor Galloway: There are a number of initiatives that are helping fishermen either to remove litter when they find it or to prevent nets and things from being lost at sea, so I think a lot of that is not intentional.

Q31 Rebecca Pow: But it is things like buoys and a very high number of missing bits of plastic. What is your view about that, because you were saying let's stop it getting there in the first place?

Dr van Sebille: Yes, I agree that the 20% is a high number. Part of that is that fishing plastic is in the ocean as soon as it gets lost rather than the microbeads, which first have to go through this entire chain of drain to wastewater treatment plant to river, so there are all these connections between that. I lost my train of thought there.

Rebecca Pow: Fishing industry.

Dr van Sebille: Yes, so that may be one reason why, if you just focus on the ocean, there is so much plastic out of the fishing industry.

Professor Kelly: I would want to have the information and break that 20% down and find out what the immediate components of it are. If one of them is fishing nets, then it sounds like a very good area where

the UK or the European Union could invest some research time to try to come up with a more durable product or an alternative product. But I think you need to know what the 20% is made of.

Q32 Margaret Greenwood: In 2013, the Science and Technology Committee heard that microplastics were relatively new and that our knowledge of them affecting the environment was limited. In your views, how far have we come since 2013?

Professor Galloway: We have a number of research projects that have now been funded in my lab, for instance, that were not funded a few years ago and I think the general perception of the problem has certainly increased. If you look at the number of papers that are being published on the issue, it is rising rapidly, which suggests that the uptake from the scientific community has been considerable.

Dr van Sebille: I think that we are not there yet in terms of what exactly the harm is of microplastics, but that we are absolutely making much progress. For instance, there was a very high-profile study in the journal "Proceedings of the National Academy of Sciences" a few months ago about oysters and microplastics, very clearly showing the link between microplastics in the diet of oysters and harm to those oysters in terms that they couldn't reproduce any more. That is the kind of study that we didn't know about before and that we now do know about, so even though there are lots of things we don't know, we are very much on track to understanding this.

Q33 Margaret Greenwood: That is suggesting it is not just about maybe the impact on human health, but also on the ability for the industries to continue?

Dr van Sebille: Yes.

Chair: So we have moved from unknown unknowns to the known unknowns now.

Q34 Rebecca Pow: We touched on this a little bit just now, but I was particularly going to look at the water treatment plants, because obviously the water goes through them. Can you just expand a little bit more on how able they are to capture the microbeads—the tiny particles?

Professor Kelly: I suspect that they are not able to capture them very well at all. We heard some evidence from America, in Chicago, where I think the normal method of dealing with sewage does not trap these very small particles. That is generally an engineering challenge, but there are some methods such as sand filtration—we are talking about particles that are smaller than the microplastics—that are able to do the job. Given the volume of material that is reaching our oceans, I would say that we are not doing that job well at all, to my mind.

Q35 Rebecca Pow: Should we be? Is this something that we should be raising and the water companies should be looking at, Professor Galloway?

Professor Galloway: I published a paper with colleagues from the University of Plymouth, I think it was in 2012, in which we examined sediments in the marine environment that were close to sewage treatment works and then compared the plastics in those sediments with the plastics that were in the sewage from the sewage treatment works and found that they were very similar. That adds to the evidence that Erik was talking about earlier, that particles are getting through sewage treatment works at the moment.

Q36 Rebecca Pow: Also perhaps, Dr van Sebille, you might be able to comment. Even when they have captured the sewage sludge, that of course is often spread on to land and then it could still wash off back into the rivers, couldn't it?

Dr van Sebille: Yes, that is my understanding of what is being done with sludge at the moment.

Q37 Rebecca Pow: How do you feel about that? How safe is that?

Dr van Sebille: Let me explain. The point that the authors of this paper—I was not involved with that paper; I just know about it—made is that although it looks like these two sewage treatment plants that were using sand filtering had their act together, that they didn't release any plastic, that was just because they didn't do it at that point; they didn't do it right there in the river because the sand filtration helped. It

doesn't mean that these plastics were taken away from the environment and that this was not an environmental issue at all.

Professor Kelly: When you spread slurry on fields, it dries out and you end up having microplastics lying on the surface of the field. There is a real possibility that some of those microparticles will be entrained into the air and they will be carried around and we will end up breathing them. So one of the areas that we have just started to work on in our research centre is to look to see if we can detect microplastics in ambient air, the same way as we can detect all these other emissions. This is a horizon-scanning issue, but the particles are of the size that they are respirable, they are increasing in number in our environment, and there is a question to be asked about whether they are also in our breathing.

Q38 Rebecca Pow: This sounds like a very serious issue. We are not laughing about it; we are laughing hysterically. This is a very serious issue then, isn't it, and it is a new issue?

Professor Kelly: It is a brand-new issue. We are not aware of any research that is being done on it. Sorry, that is not true. There is one paper that came out of Paris in 2013, where I think they actually just put a very simple collection vessel at the top of a building. They had ended up using a microscope to look at what was caught in the water when it rained in that vessel, and they found microplastics. That is just one small piece of information to say that they may be in the atmosphere.

Q39 Rebecca Pow: Engineering was referred to earlier. Do you think more effort, more innovation, more funding needs to go into this area to start looking into the capturing of the microplastics, whether it is in water, in sewage or in air?

Professor Galloway: One comment to make is yes, we could put funding into engineering, but it could also be a good news story, because we have so many talented and able polymer scientists. Once we identify the things in the plastic that may cause harm or may make them behave in certain ways in the environment, we are perfectly able to design those polymers to be safer or to degrade into something that doesn't cause harm, and by doing that we can have a positive effect on the environment. So the more we know, the more likely it is that we can design out some of these things that are causing or potentially causing harmful effects. It does not have to be a bad news story.

Q40 Rebecca Pow: I am very pleased to hear that. Finally, do you think it is a short-term fix? Is it something that could be addressed quite quickly and what would be your view of how that could happen?

Professor Galloway: It would be very interesting to see what effect the plastic bag charge has had on the amount of plastic littering the environment, because the suggestions are that with this very small change in policy, we have made a massive change in the amounts of plastic entering the environment. That suggests that there are very positive things that we can do to change behaviour, because a lot of the problem of plastics in the environment is caused by not thinking about how we are littering or disposing of things and with some small changes we can make big differences.

Dr van Sebille: Tackling the marine plastic problem is about identifying intervention points: where is it most efficient to intervene and where is it most efficient to do something about the release? That intervention is probably the closer you are to the circle or loop of plastic used in our everyday life. Plastic is a fantastic material, of course; you really would not want a society without plastic any more, but we need to make sure that there is no leakage out of that tight loop between the using of plastic, maybe the recycling of plastic, maybe the incinerating of plastic. The closer you are to that with your intervention, say the sewage treatment plant, or better plastics that biodegrade faster or that are less harmful to marine life, that is where the solutions lie.

Q41 John Mc Nally: This is extremely interesting, and following on from everything else we have been involved in, they are all connecting up. The small size of microplastics themselves means that they can be ingested into marine life. As we have just been hearing, they are getting washed out into the sea through the rivers. What harmful effects can this have on the marine environment and are these ecological effects irreversible?

Professor Galloway: A lot of the studies that we have done have been using animals at the base of the marine food web, things that normally ingest particles, and what we have been doing is studying things

like oysters and worms and small zooplankton. They normally ingest particles as part of their diet. When we add small quantities of plastic to their diet, what we find is, perhaps predictably, that they put on less weight, so if you look at them over a long period of time they grow less well and then they reproduce less well. It is a question that some of them cannot distinguish between what is a plastic and what is an item of food. Is it ecologically significant? It may be at some locations, at some heavily contaminated sites where there are organisms and plastics and contaminants all in the same place. Is it likely to occur across the entire ocean? Probably not, but without doing the initial studies, we cannot then predict what the longer-term effects might be.

Dr van Sebille: I was part of a study where we did a literature study on the effect of plastics on birds and seabirds. We found that 80% of seabird species ingest plastic into their stomach, and that if you weigh that plastic, the amount of plastic that a typical seabird now carries around can be up to 10% of their body weight. We don't know how harmful this plastic is ecotoxicologically, but it is likely that just the weight burden of a bird flying around with so much plastic in its stomach is going to have an energy demand on that bird.

Professor Kelly: Obviously after we have some of these lower lifeforms eating the plastic unknowingly, they themselves are eaten and they end up maybe in a human food chain, so the plastic ends up being accumulated in these organisms up through the food chains and ends up in our gut. The issue then is what happens to it at that point and that is again one of the areas that is just beginning to be looked at. We have defence systems in our gut, an epidemiological surveillance system in areas called Peyer patches, and again, work is being started to look for the presence of plastic in the human gastrointestinal tract.

Q42 John Mc Nally: Just following on from that, the impression we are getting here is that the bigger the marine life, like a tuna or a dolphin, the more able they are to survive that, whereas oysters and mussels are maybe more likely to suffer because of their smaller size. Is that about right?

Professor Galloway: There has been very little research done into large marine invertebrates. We just do not have enough information to be able to say.

John Mc Nally: They are processing it more easily, perhaps.

Professor Galloway: Yes, I suppose the relative size difference.

Q43 John Mc Nally: What scale of ecological impact are we talking about and how much of a priority should microplastic pollution be relative to, for example, clearing up the large pieces of plastic you mentioned earlier, or should we be addressing the chemical flows into the sea? I am chair of the all-party parliamentary group on hairdressing. It sounds quite laughable, it puts a smile on people's faces, but I think you have been at a couple of the APPGs and we have professors from Southampton University who have talked about the amount of wastewater that goes down sinks, and you are talking about microplastics in the air. Probably every salon and every room in every house is using some form of hairspray, which you are talking about, the particulates that are in the air. Are they getting washed down through the system, going right through the filtration system and out into the ocean?

Professor Kelly: If they are not biodegradable in an aqueous environment, yes, they will be, in large quantities.

Q44 John Mc Nally: Where do we start? Do you start with the big bits of plastic that are there or do you start with the chemicals? Do you cut that out as much as you possibly can? Is this a chicken and egg?

Professor Kelly: We have touched both ends of it. At the moment we think the microplastics in that form can do the most damage in a number of different ways. Yes, somehow reducing at source would seem very sensible, and at the same time, if there are large areas where this is accumulating in the ocean, it may be relatively easy to clean up. Nothing is easy, but if the ocean has done the job for us, then there may be a programme that would be appropriate to remove large quantities in a relatively straightforward fashion.

Professor Galloway: It is probably quite helpful that in terms of plastic pollution you can see it, so it is quite emotive because of that, but it is emphasising the fact that plastic is just one of the things that we throw into the sea and it is perhaps raising our awareness of all the other things that we cannot see.

Q45 John Mc Nally: You mentioned the 5 pence on plastic bags. I think that people do want to be led and that has been quite successful. I know in Scotland the amount of litter that we throw away is a national embarrassment, and if you can start tipping the scale towards people thinking that this is all wrong, I think you will start to win the day a bit better.

Are some types of microplastics more harmful than others? I think you might have talked about that a bit earlier.

Professor Kelly: It is at the cutting edge of research, but there are three things. There is the type of plastic and some—Tamara will tell you shortly—are worse than others, we think. There are the chemicals that they have been impregnated with or not and then there is the size, so those three issues come together to give you probably the most toxic form.

Professor Galloway: Certainly from the studies that we have done and that are already published, the plastic types that contain more additives have caused more problems in the models that we have been studying. Polyvinyl chloride, for instance, contains a large number of different additives and we have seen it causing a level of inflammatory change in some of the species that we have studied, where we have not seen that effect when we have studied other kinds of plastics, like polyethylene.

Q46 John Mc Nally: As Tamara was saying earlier on, it is like planned confusion when you read the back of a bottle or a tube of anything; it is ridiculously difficult to try to follow.

Other than ingestion by organisms, what other concerns are there over the potential ecological effects of microplastics and how damaging are they?

Professor Kelly: I touched on the fact that if they become airborne we could breathe them in. Up until very recently, we have just been worried about the ingestion through shellfish and other molluscs. If we can breathe them in, they could potentially deliver chemicals to the lower parts of our lungs, maybe even across into our circulation, in the same way as we worry about all the other vehicle-related emissions these days.

Dr van Sebille: There is also an effect about plastics on the sea floor that we have not discussed, but that might be quite relevant. You should not think about the sea floor as dead and barren. There is a lot of life on the sea floor and the sea floor plays an important part in sequestering carbon and in the large-scale carbon circulation of the climate. If there is more plastic on the sea floor, the animals that scurry around there and work in this ecosystem have a problem with that; they can do their job less well, their burrowing and moving around of stuff.

Professor Galloway: I was just going to say I think it is the sheer volume of plastic waste that is in the marine environment that is an issue, because it is a different kind of substrate, it is able to bind things, and because it is very buoyant it moves around quite rapidly. It may be moving things in different ways that make it harder for us to predict or make it imperative that we try to understand things. It could be moving contaminants or it could moving microbes or other invasive species that bind to the surface.

John Mc Nally: It could bind on and then move through the ocean.

Professor Galloway: Yes, and then because the plastics are buoyant and because they are able to be used by the wind and by tides, it could be moving them around in unpredictable ways. That is one of the ecologically important things we need to study.

Q47 John Mc Nally: There was an article—I did not see it, but it was on the radio last week—about an area off the west coast of Scotland, I think it was Langland Beach, where they had a huge amount of these microplastics that were visible to the naked eye. I know that a shellfish study has been done and they were trying to reintroduce them and protect the shellfish in that area. I do not want to be alarmist in any way, but you wonder why it would be in that particular area. Peter Heaton-Jones talked about Ilfracombe earlier, so is the west coast maybe getting it worse and are we at a level yet that we know where it is coming from?

Dr van Sebille: The amount of plastic that gets on the beach can vary from beach to beach and it is very much about the local circulation. You could be on one beach where there is a lot of plastic and the next beach around, just because the headland is slightly different, creates a completely different circulation.

There are two things: there is plastic getting from the ocean on to the beach but there is also plastic staying on the beach on the next high tide. For there to be an accumulation of a lot of plastic on a beach, it is not enough to just have a high concentration of plastic in the ocean; it also needs to get beyond the high tide line. That is about wind and waves, these kinds of things.

John Mc Nally: The whole mix of them.

Dr van Sebille: It is very much fine-grain detail once you start asking about specific beaches.

Q48 Margaret Greenwood: I visited a Transition Town group in my constituency on Saturday. They have started a beach litter-picking scheme locally and they are on a mission to remove litter from the beaches around the edge of the Wirral. Is that something you are aware of happening elsewhere around the country? It was something new to me and I was quite impressed by their determination.

Dr van Sebille: Yes, there is a lot of litter-picking going on on beaches around the country here in the UK, and in other countries. In my opinion, this is a very good way to clean up the ocean, because it is a very cost-effective way of getting plastic out of the environment just by walking along a beach, again coming back to the point that most impact is near our coastlines, so plastic near a coastline is much more harmful than plastic far out in the open ocean. If we grab it on the beach, then the next storm cannot wash it back into the ocean and it cannot do more harm there.

Professor Galloway: There are a number of initiatives run by voluntary agencies, and there is also one, in reply to your question, called Nurdle Watch. Nurdles are the tiny pearl-like objects that are used as raw materials for plastic and they are used to transport plastics from place to place. If they spill out during manufacture or while they are being transported, you can find them and you can recognise them on the beach. There are a number of different organisations that promote the public to go and do these nurdle watches and try to find nurdles and then report them on their website. It helps to track where they are going and it helps the manufacturing industry to identify where they are going as well.

Chair: We are going to move on from the nurdles.

Q49 Peter Aldous: I wanted to look at the potential impact of microplastic pollution on human health. Professor Kelly, I think some studies have shown that food consumption might lead to some exposure to microplastics. What do we know about the potential health implications to humans?

Professor Kelly: We know that the gut is very well protected against the external environment and we deal with a lot of what would be very noxious organisms on a normal basis because of our immune system. The problem is that whenever that immune system is tricked into dealing with something else, its attention is taken away from maybe other challenges. The thought process would be that if this non-degradable or very low time degradable material is being dealt with by the immune system in the gut, then we will be more susceptible to other food-related challenges.

Q50 Peter Aldous: Where do you think we should be focusing our efforts in order to understand microplastic toxicity?

Professor Kelly: I think one of the big advantages has been the recognition that some of the food that we eat contains microplastics. That has led to more research on those areas. I think what we need to do as a next step now is to understand whether those microplastics are staying within our body and what the sort of contamination level is on, say, a normal shellfish eater, and of course this will vary by nation. There have already been some estimations on that between ourselves and the French and the Japanese and so on, but we need some real examination of that.

Q51 Peter Aldous: What does the evidence we have suggest in terms of possible transfers to the food chain?

Professor Kelly: This is more Tamara's area, but studies have been done.

Professor Galloway: There have been some studies done that have attempted to look at the concentrations of microplastics in food intended for human consumption. Studies have been done, for instance, on oysters and mussels taken both from fish farms and from the north Atlantic. There have been some estimates that

if you were to eat an average plate of six oysters, you might consume 50 microplastic particles. That is taken as an estimate from the number of plastic particles that have been found in seafood. We do not know whether that causes any impact on human health. We have no evidence either way.

Q52 Peter Aldous: Do you feel there is sufficient uncertainty that the Government should be taking a precautionary approach in relation to food standards?

Professor Galloway: Yes, I think if we know that there are plastics in seafood, we probably would like to know what they are doing. If they are not causing any harm, it is just as important to know as if they do potentially carry contaminants with them.

Peter Aldous: You would agree with that, Professor Kelly?

Professor Kelly: Yes.

Q53 Peter Aldous: Defra's evidence suggests that we are more likely to breathe in microplastics than consume them through food. Do you agree with that analysis?

Professor Kelly: I am not aware of that evidence base. I would be very interested to look at it.

Professor Galloway: I am not aware of that evidence. I do not know that we have enough information to be able to comment.

Peter Aldous: If we can get that that would be great, then you could provide a comment on it.

Chair: Yes, that is not a problem. We can certainly let you have a copy.

Professor Kelly: I am very happy to respond to that.

Peter Aldous: That is fine.

Q54 Chair: That is brilliant. Particularly coming back to what you said, Professor Kelly, about the slurry, the atmosphere and so on and the very beginnings of this, I thought when you said that you were going to talk about soil contamination—which is something that the Committee is very alive to at the moment as well—it was going to turn up in carrots, but when you said breathing, that was certainly a surprise to me. Thank you.

What estimates do we have of the economic costs of microplastic pollution? Some estimates go as high as £500 million a year. Where do those costs come from and how robust do you think those estimates are? Is it just finger in the wind? Anybody? No?

Professor Galloway: I think UNEP has made some estimates of how much that would cost, but I am not—

Chair: The United Nations Environment Programme, yes. Margaret, would you like to move on to the next question?

Q55 Margaret Greenwood: We see action being taken by the Government and organisations to reduce marine litter. What action can be taken to reduce microplastics?

Professor Galloway: I think most of the actions that would reduce marine litter will reduce microplastics as well.

Professor Kelly: Obviously control at source, the use of them in products, if there can be more examination of the need for them.

Q56 Margaret Greenwood: Examination by—

Professor Kelly: By Government, by the EU. Why have we moved away from natural ingredients in favour of them? If it is simply monetary or shelf life or whatever, then there are questions that could be asked.

Q57 Margaret Greenwood: Would you like to see a more direct impact on policy in relation to that question?

Professor Kelly: Yes.

Margaret Greenwood: Did you want to add something?

Dr van Sebille: I just wanted to reiterate that in my view, this is about keeping the plastic within the economic system where it has a use and trying to prevent it from leaking into the environment. The further upstream you do that the better it is, and that can indeed be a 5 pence bag price or it can be a ban on microbeads, as you are considering here. On all of these it is a bit of an "all of the above" answer, I think.

Professor Galloway: I think it is largely a waste management problem.

Q58 Chair: The US has done the ban. What evidence is there that it is working, what effectiveness has it had, or do you think it is too early to tell?

Professor Galloway: I think it is too early to tell.

Dr van Sebille: I am not sure. It is certainly too early to tell what this does in the environment. Yes, we do not know yet because we have not measured it, but if you go online into the app that you referred to before, there is an enormous list of companies that have voluntarily phased out microbeads. They say it is voluntary. It may be related to the ban in the US or not, but just in that sense—

Chair: Behaviour change.

Dr van Sebille: —behaviour is already changing, so there is an impact right now, because these products are not being developed and in many cases not being sold even any more, so there is an impact, absolutely.

Chair: That is helpful. Sorry, Margaret, I interrupted you.

Q59 Margaret Greenwood: I suppose we are saying that we do not know what the outcome is of the American ban yet, but would you say on balance nevertheless it is worthwhile to have unilateral action or do you think it should be through the EU? Which would be the most effective?

Dr van Sebille: I come back to saying that this is international, that the ocean does not care about countries and the ocean currents do not care about whose coastline and which country. I am not in the consumer products industry and I am not aware of that, but I can imagine that for a large international company, consistency of laws and regulations would be beneficial for their process. I am not sure whether you are going to ask them also in this context.

Q60 Chair: Yes, we are. We most certainly will. Thank you for a fascinating session; I think we have all learnt a lot and are really impressed at the level of your knowledge. One of the things that you have showed us is the gaps in the knowledge and the research. Do we know enough and do we know enough to know that we need action?

Professor Kelly: We are scientists, so of course we are going to say we do not know enough.

Chair: You always need more research.

Professor Kelly: We did stumble over several questions because we do not have the knowledge yet. From my point of view, I do not know what contamination looks like in a human; I do not know what the health effects are in a human.

Q61 Chair: Where would you go looking for that, in cadaver studies of livers or—

Professor Kelly: We want to look for the presence of these materials in the gut and these Peyer patches, the lymphoid tissue in cadavers, with some knowledge, of course, of their diet and so on. We would want to undertake more toxicological-based studies using appropriate cell models that will give us an ability to compare the effects, if there are any, with other known toxicant particles like vehicle emissions. We have not started much of that work at all. There is much to do.

Professor Galloway: It has taken us several years to just work out the methods to be able to measure and identify the different kinds of plastics. Many of those methods we have taken from the biomedical field and we are using scanners and other different ways of identifying particles. I think we are just at a stage where we could start to increase our knowledge considerably.

Dr van Sebille: Everywhere we look in the environment or in the ocean, we find plastic, all the way from the sea floor to the surface of the ocean, to the ice in the Arctic, which is full of plastic. Wherever we look for it we find it, so we know there is a lot of plastic. But still we do not know where 99% of our plastic is. We only have a rough estimate of 1% of the plastic, the spatial distribution. All these questions about different beaches and how plastic goes into different beaches are very important to answer, especially if you think about oyster farming, for instance. Maybe there is something where placing an oyster farm in one location would be better than placing it in the other location and we need to know much better on many different scales, all the way from global scales to local scale, where the plastic accumulates.

Q62 Chair: When you say we do not know where 99% of the plastic is, what do you mean?
Dr van Sebille: What I mean is that all the estimates of how much plastic is floating around on the surface of the ocean gets us somewhere up to 250,000 metric tonnes or so, so a few hundred thousand metric tonnes. The amount of plastic going into the ocean in a single year is 10 million metric tonnes, roughly. That is 100 times more, so of all the plastic going into the ocean, only 1% is floating around on the ocean. We know that there is plastic on the sea floor, on beaches, in marine life, but we do not know where and we do not know how it gets there and we do not know how it moves between the different reservoirs. That is the inventory. We do not know, as an order one problem, where our plastic is.

Chair: Yes, that explains the differential that I was going to ask you about, the surface versus the total. Thank you.

Q63 Margaret Greenwood: If we know that there is 10 million metric tonnes going in every year, do we know where that is all coming from then?
Dr van Sebille: There is a very high-profile paper that came out a year ago in "Science" where they did exactly that. It is a peer-reviewed paper and everybody uses it now. It has a list of how much plastic goes into the ocean for every single country.

Q64 Chair: Who is the author of that study?
Dr van Sebille: That is Associate Professor Jambeck from Georgia Tech.

Chair: Great. We will all have that as our bedtime reading. Thank you very much indeed for coming. That concludes today's session. Thank you.