**CONFIDENTIAL**

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**AD: In the interests of getting started, it lies with me to welcome you to the first in what this series of webinars that have been organised by the University’s Birmingham Plastics Network. I’m Andrew Dove, I’m a member of that network, I am also a professor of sustainable polymer chemistry here at the university. The network is something we put together to pull together the interest in plastics from all over campus. It is an interdisciplinary team of over 40 academics that brings together chemists like myself but with environmental scientists, philosophers, engineers, linguistics, economists, artists, writers, lawyers, and many other experts in many other fields.**

 **What we want to do at Birmingham is holistically address the global plastics problem and see it as a challenge that needs all of these different inputs to do just that. Today, we’ve got a representation from across campus, of several different areas, including a guest with us from Reckitt Benckiser, we are grateful to have with us, to hopefully spark some debate and thought. In this particular session we’ll focus on the plastics lifecycle, so, we’re bringing together experts from industry and academia to do this. We will start with the plastics lifecycle today.**

 **There will be plenty of opportunity for a Q&A session, specifically, we’re going to hold a single Q&A session at the end of the panel meeting, so, each of our panellists, who I will introduce as we go through into their presentations, they’ve got a short presentation. Feel free to enter a question in the chat function or the Q&A function at any time, and we’ll come back to what we can get to at the end of those presentations.**

 **I’ve spoken for long enough already and what I want to do is allow you to hear from our experts that we’ve got assembled and so, I’m going to ask our first panellist, Martin Settle to share his screen and begin his presentation. Martin is the global research and development packaging sustainability manager at Reckitt Benckiser so, I think he will bring us a really interesting viewpoint on the plastic lifecycle. Martin, over to you.**

MS: Hello everybody, my name is Martin Settle, I’ve been asked to speak on sustainability packaging and consumer trends. I am the current manager of polymer science packaging for sustainability. Previous to that, I was the global packaging sustainability manager for Reckitt Benckiser, so, hello to everybody.

 There are a lot of misconceptions about who is to blame and who is responsible for the environmental waste, my view is the consumer has a stake in the waste and the plastic waste that is being generated, it is not solely the responsibility of industry, although industry plays a big part, there are also other players in this field, NGO’s, and media, who are giving information out. Retailers who stock the product and sell it, and then legislation, and there is lots and lots of legislation that is driving changes. What this actually means is that companies like mine are setting ambitious sustainability commitments and targets and we’re developing new strategic partnerships across the range of industry, from research and universities, all the way up to retailers and consumers.

 Who should be taking the lead in finding improvement and solution? This is a report that has been done externally by Tetra Pak and is one of many reports that are available on the internet, but this one is specifically around packaging. As you can see, government is playing a major role in what is going on and driving the changes from a governmental point of view. Food and beverage companies, packaging companies are also major implications in this and are being targeted by the consumer who should be taking responsibility. But also, the consumer needs to take responsibility for finding improvements and solutions. We can’t do it all and we don’t make the choices about what the consumer buys and what the consumer puts in the waste.

 This is really to show that there are lots of people interested and lots of interesting parties that are interested in the discussion. Yes, the fact that people want government to lead it and industry to lead it is great because we are doing, but also, the consumer has to play their part, else we can make the greatest packaging or plastic, the government can legislate for it, but if you’re still throwing it in the river, you throw it in the river. So, all industry, regardless of source is now heavily focussed on looking at future ideas for packaging, and how we get there, the building blocks to get there.

The real drive is to move away from fossil-based plastics, so, crude oil, and single-use plastic and move towards materials that are solely made from renewable and recyclable packaging materials, ensuring that wherever possible, and not everything is possible, but wherever possible, everything is fully recyclable. That the emissions, especially when it comes to Co2, are as low as we can possibly make them. Now, the reason we say renewable sources, and fully recycle is because it takes these products away from going to landfill and incineration. It secures the environment against the environmental impact from these materials. So, you’re looking at renewable packaging, so, packaging that can be either used more than once or the material from it can be used multiple times to make different materials and making sure that everything we do is sustainable and has a minimum impact on the environment.

There is a big push towards a circular economy, the circular economy is really good, but there needs to be a lot of education to the consumer and government to make sure that the circular economy works, and that people are recycling the right products in the right way. As industry, we design products that can be recycled in the right waste stream. This is a step-in development, and it is going to continue growing and developing over the next 5 to 20 years and is really the start of the journey to building infrastructure, to build a recycling. But it has to go hand-in-hand with education because if the consumer is not educated and picks the wrong product and disposes of it incorrectly, we can do all this work for nothing. And actually, the consumer can put something into a waste stream that ends up contaminating the waste stream, not making it recyclable.

So, I just wanted to give a bit of a look at how, as industry, the timescales involved, the work that has gone on in the background to develop new products. So, as you can see from the timescale, we’ve got lots of new product developments out there and this is just a snapshot, based on some of the work that Tetra Pak did. From biodegradable caps which are now nearly 10 years old, or fully recyclable cartons to cartons with antiseptic on the outside, materials, and cartons and bottles with biodegradable coatings, on materials that have barriers that were thought to be recyclable and biodegradable but aren’t to probably renewable sources that actually come from organic feedstocks. So, things like sugar cane, banana leaf, and sugar beet and are now, looking at being renewable, removing fossils.

There is a cost to this technology, there is a cost to developing this technology and it is not commonplace. It is becoming more commonplace, but that cost has to go somewhere, and at the moment, it’s going to the consumer. So, the consumer has a choice whether they need that material or want that material, or whether they, as consumers, are prepared to pay the additional costs to have fully recyclable environmentally friendly products.

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This is to give you an insight into the use of recycled content. Now, we could have picked any product here, but I’ve picked a cardboard box because everybody knows what a cardboard box is. Every cardboard box has recycled material in it or else it wouldn’t work. It’s not getting the recycled material into the box that is the problem, it’s getting the right recycle material into the box at the lowest risk and the right grade that is the problem. And what you can find and what is demonstrated by this slide is, not everything works and not everything can be put back into primary packaging and some things will have to go into secondary packaging and be downgraded. It’s the same whether we pick a plastic bottle, whether we pick flexible film, whether we pick glass; all of them can be recycled to a certain extent, but not all of them can be reused for primary packaging. So, again, the recycling chain and the circular economy, by putting the right thing in the right recycling stream and giving the consumer the right information to make the right choice and place it in the right stream, is vital.

What we do, as industry, is help the consumer make these decisions. So, what we do is help by designing in recyclability at the end of life into the products we sell. So, instead of just simply thinking what is the cheapest bottle we can get, and the cheapest material that does the job, which is the old way of thinking and making it as light as possible, we now, still want it as light as possible, and we’re reducing the material we use, but now, we think, is it recyclable, does it have a circular life, can it be designed for reuse? Every company, every major PLC across the world now has sustainability requirements and pledges aligned to NGOs, aligned to government requirements and legislation. I want to take away the myth that we’re sat on our laurels and being forced to do it, we’re not, we are constantly developing new materials, we are constantly pushing the envelope on sustainability and the environment.

The problem with most of these things, there is an uplifting cost and we, at some point, will end up passing these costs on and at some point, somebody will have to make a decision on where these costs go. Until these products become the norm and become the mainstream, there is always going to be a cost implication to this. But we are developing new mono-materials, new single-use plastics that are fully biodegradable, compostable, recyclable, new materials from alternative B stocks, tamanu oil from forestry, and organic oils and fungi. But also, we are ensuring that there is a full supporting life story behind everything we do and using life cycle technology and digital solutions to support the assumptions and data of conclusions that we come to. So, when we do something, it is validated, it is proved and it is shown where it will stand in the right cycle and how many times it can be recycled, and what effects it will have on the environment.

So, talking about current packaging regulations. Basically, this is what everybody thinks, there is no enforcement, the guidelines are there-- all we’re interested in is light-weighting. There are different packaging rules across the countries in the EU, and it is difficult to understand. This is basically, the way it was and what has happened is we have lots of legislation to bring everybody in line, and there are lots of governmental pacts and regional packs and regional laws now being brought in to get away from all this nonsense about regulations and all the requirements. We have very strict regulations in industry, governing what materials can be used for what products. We have very strict regulations about what products are hazardous and what isn’t, and we have now, another layer of commitments, which is about what materials we use and how it is disposed of. So, there is lots of talk and lots of work going on about solving all these problems in the most sustainable environmentally way friendly, but aligning all the while to the new regulations, new directives, the new laws that are being passed to make us more environmentally friendly.

So, this is the essential requirement—this is what is coming in law and it has been passed in law and it is going to coming through all countries within the EU and starting to spread across the world. As of today, we have essential requirements that we have to meet to be—which is a legal requirement for all sorts of things including tax from waste. The essential requirements will start to be implemented from next year and this will be defined even more in the rules and come 2022, the rules will be enforced. The rules are going to be increased and there are all sorts of taxes and fines and requirements made now on industry, which will start to escalate further up until 2030, to ensure that we are responsible for the waste we generate. That we are responsible for any contamination of the products that we generate and that the material we do use is the most sustainable.

This is just a snapshot, it is not the full list by any shape, it is just to give you an idea of the timescales involved. And this is the one that is fixed in law, there is a further projection on this up to 2050. If we had gone back 5 years, there would have been legislation work on laws to get us to this stage as well. So, this is just to give you a snapshot of the regulations and laws that are come into force now for industry, which affect our choices and affect the decisions we make to supply to the consumer. This doesn’t only affect manufacturers; this also affects retailers and the choices that retailers make from the products they buy to sell to you the consumer.

This is an example of what Tesco has done. Tesco’s have introduced their 4 R’s programme, Remove, Reduce, Reuse, and Recycle. Basically, they’ve laid out the law to say, we want to be more ethical, [unclear 00:17:40] to sustainability, we want to be clearer with a message to the consumer. But also, we want to be one of the forces driving change through the manufacturing chain. But also, they want to mitigate the effects on them financially from not doing this. When you go to Tesco stores, you will see signs like these—they are promoting what they do, they are promoting the 4 R’s, they are promoting the message; a) this is good for them to do because they are a driving force in consumer choice, but also, it is a legal requirement under the new directives in the EU and across the world, that we have to educate and communicate clearly, the recycling message. So, you will start to see a lot of the big retailers doing this, you will start to see a lot more on [unclear 00:18:37] doing this and the message will become clearer, and clearer, and clearer. This is all about making sure, you as a consumer have the right information to make the right choices, to pick the right products, and to put in the right waste stream.

So, Tesco has initiated the 4 R’s programme, and they have pulled together a red, amber, and green list of plastic materials that they want out of their business. Now, this is just an example of some of the plastic materials and products that they want out of their system, and out of their stores to help the consumer make the right choice. So, as you can see, there are sorts of materials there, I’m sure you’re shocked by some of the products and what they contain, but basically, a tab of blisters-- the majority have PVC based. That is because it’s cheap, it’s durable, and meets all the medical requirements to have a tablet blister; it is strong enough, but it is still poppable and it does all the things that we want. There is not a viable replacement for PVC at the moment and it is a medicine, so, the restrictions placed on a pharmaceutical company are huge, to make sure that whatever we pack it in, is inert, that it does the job it is supposed to do which is protecting the goods and making sure that the pharmaceutical inside works and is not affected and that the product we change it to, has no adverse effects.

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So, there are lots of regulations that govern some of the decisions we make and some of the things that are on here will not be overnight successes, there will be lots and lots of work in the background to make these changes happen. So, this is an expansion of what Tesco’s are doing, and Tesco’s are not the only ones doing this, all major retailers are doing this. Just to show you some of the background work that is going on to move products from red, amber, and green. Green are products that are accepted, that are recyclable, and have no issues with being in the recycling chain. Amber, are products that have question marks over, and there are lots of products out there and plastics that have question marks over, that either need verifying that they are green or need confirming that they are red and need removing. So, this is a constant process, backwards and forwards between red, amber, and green materials to make sure that they are as sustainable as possible.

One thing I wanted to point out is black, black plastics are not the devil, one of the components in black plastic is the devil, carbon black because it contaminates the waste stream and gives false readings. But black plastics are not the devil, it’s just one part of it. So, again, that is about consumer choice, consumers make an informed choice, not the choice that is based on half-cut information that is out there.

This is the green list, so, this is a list of products that are acceptable by the big retailers, this is Tesco’s example again, that are highly recyclable, that have a second life, and have been thought about from the end of life. All we do is design with recyclability and efficiency in mind. We design to makes products as recyclable as we can, and if we can’t make them recyclable, we can make them reusable, if we can’t make them reusable, we make sure that they do not harm or limit the harm they do to the environment. Now, we can do all this work and manufacture products from the most environmentally friendly products in the world. But if the consumer still makes the wrong or is ill-informed and picks up a bottle, or a cap, or a product, or a packet of crisps and still throws it on the ground, I can’t do anything about that. The parting line I’m going to send you is, you hear all these things about things in the sea, the oceans, the rivers, etc. Those products didn’t commit suicide and dive into a river, a bottle does not walk itself into the sea, somebody drops it on the floor, and that’s the consumer who drops it on the floor. So, thank you very much for your time, I really appreciate the opportunity to talk through my views on packaging and the consumer aspect of packaging in plastics. Education is the key, more understanding is the key and making sure that we as manufacturers are tuned to what the consumer wants, but also, confirm that we are designing the most sustainable products we can, within the constricts of the regulation clause [unclear 00:23:45]. So, once again, thank you very much for your time, I appreciate it.

**AD: Martin, thank you very much. We’re going to move now onto Natasha Cornea. Natasha is a University of Birmingham lecturer in human geography, Natasha, I’ll hand straight over to you to tell us from your viewpoint on this.**

NC: Thank you very much, Andrew. My research largely examines environmental politics and urban governments, primarily in South Asia, although I’ve done some work in Zambia as well that I’m going to draw on today. With people thinking about how urban environments are governed and controlled and the politics in particularly of solid waste management, that the plastic problem intersects with my own research. Today, I really want to suggest that by framing plastic waste as a problem to be eliminated, we really risk, I guess focussing on technical fixes and overlooking the people who are already involved in managing this problem, particularly when thinking about plastic waste in the global south we risk marginalising a whole host of actors in southern cities, including waste reclaimers, or what is often referred to as waste pickers, and the informal and small-scale recyclers who, through a wide range of practices, provide really a crucial, yet undervalued service to cities.

 I want to suggest that to effectively and equitably address the challenge of plastic waste, particularly in the global south, we need to incorporate these actors and their contributions both into policy and sociotechnical interventions. In short, we need to live up to the belief of a recyclables broker in Lusaka, who assured me that these people at Lusaka City Council know we assist the photo here is of the Lusaka landfill. So, there is a lot of risk in a short talk like this of lapsing into really broad generalisations, when in fact, the realities of how plastic waste, in particular, becomes a livelihood resource in the global south. There is quite significantly—and I want to illustrate that with 2 examples here.

 So, my research in small cities in West Bengal revealed multiple and diverse points where recyclable materials are diverted from waste streams. High-value materials, things like metal and glass are often diverted at the household level. Whereas as relatively low-value and bulky materials, particularly plastics, things like bottles, discarded flip flops and packaging, really enters the waste stream where it is removed by waste reclaimers at community rubbish points, and layered directly at the landfill, like you can see on the left-hand side of your screen here. So, that waste, at the landfill is collected and sorted by reclaimers into quite finely grained categories. And this relies a lot on the skill and embodied knowledge of these labourers. Before it is sold onto brokers, who often then further sub-divide this waste, into really, really remarkably fine categories, in order to sell it onwards to recycling firms and their agents.

 In India, waste reclaimers are estimated to remove 1.5 to 2 kilograms of plastic waste from the waste stream, per day, per reclaimer. So, already, you can get a sense of just how much they remove from the waste stream. It is estimated that across India, about 60% of plastic waste—or plastics, are recycled, so, it is a fairly significant contribution. That pattern, however, is quite different in Lusaka, where I have also done work on waste workers. And there, during my research, almost no plastic was diverted at the neighbourhood level, rather, plastic waste, and particularly plastic bottles, that you can see in this photo of the Lusaka landfill, are removed from the waste stream, only at the landfill. So, at the Lusaka landfill, female waste workers, and over 75% of the registered reclaimers at the Lusaka landfill are women—collected bottles from the rubbish that made it there. So, those bottles were then sold by the sackful; and you can see these quite large white and green sacks here, to again, mostly female waste brokers, who then, in turn, sold those onto an entrepreneur, who shredded them and sent the shredded material abroad to be made into fleece, which was later resold on the Zambian market.

 So, informants both of the landfill and those working for local aid groups, indicated that this relative dearth of reclaiming was because of quite unreliable and poorly developed value chains in the country. And this is something that the reclaimers told us about as well, in that it was inconsistent. They currently had a market for it but in the past, they had lost that market. So, I don’t know of any industrial ecology work done in Zambia, to estimate the amount of plastic that these waste reclaimers are able to remove from the waste stream, but across sub-Sahara and Africa, it is estimated that only about 9% of plastic is recycled. So, it is quite a significantly less rate of recycling, than what we see, for example, in India. What is common though, across these cases and other research that I have read, particularly where there has been no intervention into this sector, that sought to exclude people from the work and exclude them from accessing these resources, is that those who rely on plastic waste as a livelihood resource, are amongst the most marginalised urban labourers. Waste reclaiming really has quite low barriers for entry, so, it is not something that you need a lot of capital, or any capital really to do, so, it is often a way to provide a much-needed source of income for those who have access to no other work, and it is one that helps households to ride out economic shocks.

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So, I’ve chosen some responses from people I’ve interviewed here to illustrate that. So, for example, a female waste plastics broker in Lusaka, explained to me that after her husband’s death, the business that they had, which dealt with medals went down. She lost a lot of capital, so she had very little money to buy medals from people and sell those on. And so now, she’s dealing with bottles, that’s how she made the switch.

 Quite poignantly, a waste reclaimer in Navsari in Gujurat India, simply stated that garbage is free for the poor and it is one of the few things that is. And while it is often this kind of livelihood of last resort or a livelihood that you fall back on, there is dignity in it and there is life in it. A male recyclable broker in Lusaka spoke about the stigma and the pride of the work they do, pointing out that others assume we are mad and suffering, he said, but when they come to the landfill, they see that there is life here. So, despite the potential to support the survival of some of the poorest in the city and the scope for the lucky to progress from reclaimer to broker, for example, establishing more viable businesses and quite crucially businesses that they would want their children to follow them into, unlike reclaiming. It is important that we obviously don’t over-romanticise this work, it is often stigmatised, the earnings are limited, and the work itself is dangerous. For example, respondents in India pointed out that there is a significant risk of contact with medical waste, in cases where those had been illegally dumped. While my respondents in Zambia, more often cited fumes and smoke through the fires that burned smouldering deep in the landfill as being a key risk of the work that they do.

I think we can probably agree that recycling isn’t going to save us from the problem of plastic waste, it’s not the long-term solution, but arguably, it is going to remain part of our strategies for quite some time to come. And thus, I want to suggest that really any equitable solution to plastics, needs to consider these actors. It needs to account for the ways they contribute to mitigating the problems of plastic waste, it needs to valorize their contributions, but in doing so, I think we also need to deal with the at times, thorny social and environmental justice issues that such valorisation raises. What I mean by that is questions like how do we incorporate actors such as these into our solutions, without in turn, creating unnecessary barriers to those livelihoods? How do we avoid, for example, unintentionally, facilitating a shift wherein those who have traditionally worked in the sector or relied on the sector, are now excluded from it, in terms of—that’s not I wanted to say it--are excluded from it, in favour, rather of those with more social, human, and economic [unclear 00:33:23]. And if, for example, we formalise recycling, where it has been traditionally informal and multi-actor, how do we already incorporate those already relying on waste for their livelihoods and already acting within that system, into new ways of working, new ways of dealing with waste? And eventually, ideally, how do we help to facilitate shifts, to new livelihoods when these livelihoods become obsolete? So, really complex questions but I do think that these are questions we need to think of from the beginning and incorporate into our-- any solutions that we offer. That’s it from me.

**AD: Thank you very much, Natasha, some really interesting thought-provoking questions that you have challenged us with there. As I said, at the end of the previous presentation and the start, please do start to fire your questions into the Q&A and I’ll make sure we reserve some at the end of this webinar for those. We’re going to move swiftly on to our next speaker, who is Professor Stefan Krause, who is a Professor of ecohydrology at the University of Birmingham. Stefan, I can see your slides up there, so, please take it away.**

SK: Thank you very much and thanks for having me and having us. I am going to talk about some work the collaborators at Birmingham and Lyon and Vanderbilt University. I have been doing an accumulation of plastic in river networks and the fate of plastic pollution in river networks in particular.

 So, why river network? Rivers are often seen as a major source—they are a major source of plastic pollution to the oceans. But in addition to being a major source of plastic pollution to the oceans, where pollution has been tracked and traced for the last 2 decades and has received a lot of attention. River networks themselves cannot just act as a conduit for plastic waste and mismanaged plastic waste, but we see a lot of accumulation in rivers and river networks, both in the surface water, but in the sediments of rivers, underneath rivers, and beside rivers. And that is where plastic stays very close to us—plastic waste stays very close to us, and it had an impact. It is basically very close to the start of many of our food maps that affect us directly. It also has potential—I am going to show you some very recent results that we are just about to publish them, to create a legacy. So, we always talk about plastic as an emerging pollutant, but what is only emerging is our awareness of plastic as a pollutant—of plastic waste as a pollutant. It has been out there for a couple of decades and even though we see an increase in concentrations, in the environment, that has happened for a couple of decades already and we have created a legacy that will outlast us. It will outlast us for several generations. I am going to show you how we can identify potential hotspots, as well as hot moments or periods of pollutants that help us to target, mitigation options, whether that is for clean up or for reducing the problem at the source, by reducing the input into the environment.

 I’ll start with some modelling results, and really, at a global scale, it has been identified that roughly 5 to 12 million metric tonnes of plastic are discharged by rivers into the oceans every year. These million metric tonnes are really difficult measures to understand; so, 5 million metric tonnes, is roughly 1 million elephants, that is a big one, African Elephants. So, we discharge-- this was data for 2010, so, it is already 10 years old; in 2010 we have basically discharged the equivalent of the weight of 10 million African elephants, in plastic, to the oceans. That is more plastic than has been detected in the ocean, because it is really difficult to detect, in particular, the smaller particles, the microplastics in the oceans.

 Only 3 weeks ago now, there are 2 papers published in Science that project that up to 2030—so, 10 years ahead from now, this will raise, even with our best intentions, to likely more than 50 million metric tonnes. That has not even included the rise that we see in single-use plastics uptakes since March this year, or February/March this year for often the medical sectors, as well as the household sector for, of course, use in the pandemic; that is not even included there. So, we see still increases in the amount of mismanaged plastic waste, not just plastic use but mismanaged plastic waste. However, if we compare that number—the mismanaged plastic waste that rivers are transporting to the oceans, that is still just a fraction of the mismanaged plastic waste. Natasha talked a lot about it before, that it is produced, and is produced on land. We know that in 2010 when up to 12 million metric tonnes of plastic were discharged by rivers to the oceans, more than 120 million metric tonnes of mismanaged plastic waste are actually being produced.

 So, where are they staying? Well, we did run a model—you can see the outcome here, the red spots are where you see a significant accumulation of mismanaged plastic waste on the land surface in river catchments. We have been tracking that plastic in our catchments for big catchments like you see, for the River Ganges here or you see from big Asian rivers, from the Yellow River to the Mekong and Red River. The majority really is accumulated of mismanaged plastic waste in river catchments in Asia and Africa. Very interestingly, when we think about how to tackle that pollution, if you look on the lower left slide here, a lot of that is actually accumulated in quite some distance to the ocean; and that is really important when we think of when does that plastic actually reach the ocean and how long does it stay in river corridors and what impact can it have in river corridors until that is happening? So, the majority is not produced only in coastal areas, basically, because many, megacities are not that close to the coastline. Some are but many are not.

 I will show you 2 results for some of the main plastic polluted river catchments in the world. On the left-hand side, that is the Mekong River, both of them are multinational rivers, so, there are lots of issues with the water management across boundaries.

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You can see that the input of mismanaged plastic waste—these are again values for 2010, it was around 50 mega tonnes. The output was just over 1, which means roughly 97% of plastics have been stored there for more than a year. For the Ganges, that’s where we are working quite intensively, with Indian partners, we see a similar value, so, roughly 90 million tonnes gone in, a bit more than 2 going out, so, again, 97% stayed in the Ganges for more than a year. And that is really important because it defines for how long plastic can accumulate there and can actually cause harm to freshwater ecosystems and of course, us, as end-users of that water. One reason why it stays so long is that the majority of large river catchments are heavily managed, so, the floor there is heavily managed. And that has an impact also when we make predictions to head into the future, we see again for the Ganges and the Mekong here, these are what we have observed and remodelled as plastic discharge from those rivers out to the oceans. This is how discharge to the oceans will appear if we stick to 2010 values. The blue lines are showing you basically an extreme scenario; what would happen if we stopped any input of mismanaged plastic into the rivers right now. We see a sudden drop but then a very long tail of still plastic basically bleeding out for easily, up to 100 years from now, which we have already stored in the river catchments.

 However, I have to highlight these are our model results, we try to validate our models as good as we can, but models are very uncertain. The first rule in modelling is in this case literally rubbish in, rubbish out. So, models can always only be as good as the data that we use to run them. In order to provide really good modelling data, what we do in Birmingham, is we run, what is called the 100 Plastic Rivers Network, where we are working with people around the globe to actually create good observational networks for plastics that are stored and transported in surface waters and in river sediments. Then we run in our artificial river on campus, a lot of controlled experiments, what is happening to that plastic, how are they leaking contaminants, etc.

 We have been rolling that out for the last 2 years, we are getting swamped with samples coming back from all over the world, and very excitingly, we managed to tackle plastic pollution in some of the largest and most polluted rivers globally. These are results and pictures here from a survey that we have done last year, at the end of November, early December, together with partners from the UK, and India, along the River Ganges, monitoring plastic pollution, basically from Haridwar, the Upper Ganges, down to Bangladesh. Where we are able to start identifying hotspots of plastic pollution in rivers, that can help us, for instance, to pinpoint really where would clean-up operations be most successful, during what times is plastic pollution the highest; how can we protect water sources from pollution by plastic from further upstream?

There is a lot of work to do here, and our work is supported, not only by a whole range of funders, research councils in the UK and Europe and the US but also, through some charitable-funding campaigns, in Birmingham. Andrew is involved in these as well and everyone else, so, these are networks that are based—who’s success is based on the contribution of many partners and I just welcome everyone to chip in here, get in contact with us and see how you can be involved in this as well. Thank you.

**AD: Brilliant, thank you very much, Stefan, some slightly terrifying, if not interesting numbers you presented there that hopefully will stimulate some discussion later. The chat questions are starting to come in so, please do keep them coming.**

 **We’re going to hand over to our final speaker of this session who is Jonathan Seville, who is a Professor of Formulation Engineering at the university, in chemical engineering. Jonathan, I will not take up any of your time, please, take over when you’re ready.**

JS: So, I’m a chemical engineer, and I’m in a group of a number of chemical engineers in Birmingham who are working on the plastic processing problem and how to turn plastic into something that realises the circular economy. We are working particularly, with a company called Recycling Technologies, and it will become clear what they do.

 I want to focus on some possible solutions and particularly on a solution called pyrolysis, a solution for how you might convert waste plastics into something useful. So, here are 3 possibilities for the thermal treatment of waste. If you simply take mixed waste plastic, that you see in the picture there, then there are 3 possible thermal treatment directions you might take. Starting on the right-hand side there, you could just burn it—not recommended. I won’t go into why; I think it is obvious. In the centre, take some oxygen out and heat, and if you get the conditions right, you can gasify the plastic waste and make a gas which contains a mixture of various things but particularly, hydrogen and carbon monoxide, carbon dioxide—a syngas. And you could pipe that somewhere and you could use that for heating or turn it into something else, that is a possible solution, and some people are working on that whole area. And then on the left, is the area that we have been more concerned with, which is pyrolysis, heating without any oxygen, which then breaks the plastics down into hydrocarbon chains and produces something which is a bit like the oil that it might originally have come from. Pyrolysis—thermochemical decomposition of organic materials, elevated temperatures in the absence of oxygen, from the Greek, pyro, fire lysis, separating, I like that.

So, how might you do this? Well, you could just pack your plastic into a pot and get the oxygen out somehow and heat it up, and indeed, there are various, even very small devices, that are advertised, which enable you to do that, even on a household level, I guess. Not likely to be thermodynamically very advantageous and probably not very good for the environment either.

Here is another solution. So, this beautiful animation, which I thought might brighten up our dull morning—dull as far as the weather is concerned anyway. It shows fluidisation, so, this is an area that we also work on quite a lot in Birmingham. If you pass a gas through a particular material, which in this case is a sand-like material, it bubbles, a bit like a boiling liquid and this is a perfect environment into which to put your plastic waste, which is then intimately contacted with a hot sand-like material. You get a good mix and good transfer and it is a very good type of reactor.

So, let’s take one of those, in principle, you just feed your plastic waste into here and you get some useful hydrocarbons coming off. However, this process requires heat; how are you going to get it? Well, the solution that recycling technologies have, is a so-called 2-pot design, where you have a thermal cracker, you see on the left there, which is the endothermic process, you have to supply heat to that. That is where the cracking of the plastic is going on and then, on the right, you have a regenerator, and you circulate your sand-like material between the two. What is a regenerator? Well, that is another part in which you heat the sand up again and return it to the cracker. How do you heat it up? Well, you could burn some of what you’re producing from the pyrolysis process itself and that is what the recycling technology’s process does.

But there could be other ways of doing that. For instance, if you’ve got essentially free energy from wind power, you could be using that, we could talk about that later if there is time and people are interested. So, is this fiction? Not at all, this is definitely a real operating process. Here it is actually 4 years ago, on Swindon Borough Council’s municipal waste recycling centre. And this is a plant which takes 700 tonnes per year of mixed plastic waste; by that, I mean the stuff that is in your bin and puts it into a hot fluidised bed and turns it into a useful range of hydrocarbons. However, 700 tonnes per year isn’t enough to be really practical commercially, and what recycling technology has done is to develop a 7000 tonne per year plant, shown schematically here, you can see the 2 pots, the first one into which you feed the plastic, where the pyrolysis is going on. The second one, where the sand is being reheated and returned to the reactor.

**[00:50:00]**

And the other things you see there are devices to take out pollutants, which we can come to. And some fairly traditional chemical engineering distillation columns and so on to separate the hydrocarbons into a range of things which would be useful; described here as chemical feedstocks. From 7000 tonnes per annum of waste, you get 5,200 tonnes per annum of chemical feedstocks.

Here is a simple schematic of a 7000 tonne per year plant, which is currently under construction in Ayrshire in Scotland, funded by Zero Waste Scotland. And the thing just to note there is if you were going to do this seriously for the UK, you would probably need about 200 of these plants, which is kind of similar to the number of really large municipal waste recycling centres, not surprisingly. We could debate for a long time how big is the right size for a plant like this because clearly, it needs to be local. This is not the kind of thing where you’re going to have 3 or 4 of them like you might have national refineries, for example. So, what you see there is the various components are inside what is called ISO containers, so they’re prefabricated in a factory and delivered to site as pretty much whole processes which are stuck together like Lego.

To go the bigger picture then, what you want to realise is a circular economy here, you’ve got plastic products coming in—the left—you’re using them in the home, you’re throwing stuff away, it’s being collected. Some of it is sorted and sent for mechanical recycling, which is your first choice thermodynamically, some of it is going to—what is in the centre there, the RT7000, described as a feedstock recycler, that is the term that the industry uses because it turns it into feedstock for other things. You can see other things being rejected here, like water, char and ash, heavy metals, halogens, and so on. As I say, we can talk some more about that; that is important. And then that produces your hydrocarbon product which could go directly to a refinery or could be transferred into some other kind of manufacturing process, where again, you may have removal of pollutants, which refineries are very good at, actually. And the result of that can be your virgin plastic again, which can be used again to make a plastic product. So, that is your circular economy.

To show it a different way, if you look on the left, this is the situation right now that plastic is 12%-- this is in the UK, or something like that, it goes into mechanical recycling. Pretty well zero goes into what we would call feedstock recycling—sent back to the polymer manufacturer as a substitute for oil, which means 88% is going into the things you don’t want. On the right here, you’ve got something which we think is realisable, where you might reduce that to only 10%, you do a lot more mechanical recycling and you certainly do quite a lot of what we call here feedstock recycling. So that, in a nutshell, is what we’re working on and of course, there are all sorts of issues about what I’ve just said, which I expect people will want to pick me up on, in the chat. That’s it from me.

**AD: Thank you, Jonathan, a really great overview there. We’ve got some questions coming in and we will do our best to answer some of them. I’m going to start with a question, which I think is probably most appropriately phrased to Natasha because it came in immediately after your presentation. It is quite an interesting point of view, says the question; what is the plastic split in households in developing, versus developed countries? I was thinking along the same lines myself in terms of where is this waste coming from that you are seeing in these developing countries.**

NC: That’s a good question. I don’t have a number for developing versus developed countries. We do know from various studies that have kind of quantified the waste stream particularly in cities in India which is probably the bit of research that I am the most familiar with, is that the amount of plastics and other recyclables that make it into the waste stream are significantly higher in neighbourhoods that have higher incomes. So, relatively little going into the waste stream in low-income neighbourhoods, quite a bit going into the waste stream as income rises. So, I would expect that we would see a similar pattern globally or on a per-country basis, obviously, with some variability of how well-established recycling programmes are. I’m kind of shocked and appalled by Jonathan’s statistics that 12% of plastic is recycled in the UK. But I would expect that we would see similar patterns with the composition of waste.

**AD: Thanks, Natasha. I think a lot of these discussions highlight that there is an awful lot of work to do, hence one of the reasons for the Birmingham Plastics Network being in place to help us address these. Stefan, did you want to come in on that?**

SK: Yes, just a very brief one because there is sometimes, the perception that low and mid-income countries are the main sources of plastic pollution, and a lot of plastic pollution enters the environment there. But we need to be honest probably as well as consumers, that a lot of plastic pollution where it is entering the environment there, has not been generated as pollution over there, but has been pollution that basically, we traded over there. China has just closed the doors to that, I think, 2 years ago or so—but that caused a shift towards southwards basically, to South East Asia. And of course, the majority of our consumer good productions is not happening in Europe or in North America anymore, but over there. That means that a lot of production, particularly, the fashion and textile industry, is happening in South East Asia, where we see this huge [unclear 00:56:44] burden as well maybe to a degree, luckily, that also means a lot of the companies involved there—we make really good experiences there. For instance, in Vietnam, we have fashion industries that really want to be part of the solution and helping to reduce the plastic waste burden to the environment. It is not all domestic waste that is produced by people over that, a lot of that actually, is produced by us, or for us.

**AD: Thanks, Stefan, that is a really important point to make. Jonathan, you have attracted a lot of interest in the questions. I’m going to pick the most controversial one to go with first. The question is, don’t you think that technologies that transform plastic into useable products are politically dangerous; that might give plastic pollution an incentive, especially keeping in mind that both production and recycling—downgrading is considerable energy on one side and politically incentivising plastic use on the other side. What is your response to that, Jonathan?**

JS: Well, okay, I think it is a very complicated picture. There are a lot of things we need to do; we need to stop using plastic in areas where it is inappropriate to use it. But I think stopping using plastic completely is not likely to happen and probably isn’t what we would want to have happened either given the beneficial uses. So, you’ve got to find some way of generating a sustainable economy in plastic use. What I’m sure the people at recycling technologies would say is you are substituting for virgin plastic being made directly from fossil fuels. So, there are, of course, environmental advantages in doing what I’ve described. I think you’re saving something like 2 tonnes of Co2 per tonne of waste plastic recycled if you can do it this way. Is that an incentive to people to use plastic more? I suppose the economics come into that and I can’t help thinking that plastic is going to become more expensive actually, and it probably should be more expensive because we need to factor in the kind of environmental considerations that we’ve talked about. That would act as a disincentive to increase it to use.

**AD: Thank you, Jonathan, some really interesting points raised there. If I may throw in my own two-penneth into this discussion that, quite a lot of plastic products were invented to help the environment, the plastic bag being one that has a lower environmental footprint until we dispose of it at least than paper or even cartons. So, there are environmental benefits to using plastics because it is cheaper because it is less energy-intensive to recycle. But a lot of these factors get lost and forgotten about when we look at the environmental impact of our poor disposal of that plastic has on this.**

**[01:00:00]**

 **So, potentially, better recycling of plastics actually, reduces our need for fossil fuels and reduces our environmental impact of any other material as well.**

JS: Yes, I agree with you absolutely, and I think an important point I should have made is that you shouldn’t do any of these things without a thorough lifecycle analysis to work out what the net consequences really are of what you are doing, including substitution of products. A lot of the solutions that sound obviously right are actually not right when you do the sums.

**AD: Thank you, we are running out of time. Martin, I hope you’re still with us, I can’t see you on my screen, but we’ve got a question that has come in for you, that I’ll pose; hopefully, you’ll be available to answer. You say that consumers are at the heart of everything you do, but considering the failures highlighted with our plastic pollution and recycling rates, should you place the environment at the heart of your decisions instead?**

MS: The environment plays a part—but who puts the rubbish into the bin, who drops the rubbish on the street? It’s not the environment, plastic bottles don’t commit suicide and jump into a river, it is people. So, if we don’t bring the consumer on the journey, the environment is not going to happen, it’s as simple as that because the consumer makes that decision to drop it on the street, put it in the bin, to buy that product from the shelf. So, the consumer is central to that environmental story, if they don’t understand it and are throwing things away that they shouldn’t, or not making the correct choices, the environment is on a [unclear 01:01:45].

**AD: Thank you, I think that is a really important point you make. I always say plastic is not the problem, we are. Of course, plastic is part of the problem, but we are probably a bigger part of it. I’m going to try and squeeze one more question in here because I think there is some fascinating discussion. Probably, it’s more likely that Martin, and/or Jonathan might want to come in on this. What focus is there on reducing the complexity of plastics, i.e., mixed material? We have medicine blister packs, plastic plus foil that are ubiquitous; black plastic food trays, try saying that in a rush—household recycling doesn’t collect, even the humble Pringles tube. What is your comment about the complexity of plastics that we produce and use? Martin or Jonathan, do you want to come in on that?**

MS: I think the easy thing is, it is historical--we’ve gone back 20 or 30 years to where the push was to reduce, reduce, reduce. By doing that, we invented new plastics and new applications for them. The process change, there is lots and lots of science being thrown at new material technologies, lots and lots of research being done to reduce complexity and it is in the throes of being done. Some things are out in the public, some things are hidden away in labs, in universities, and in industry, but I can assure you that from a manufacturing point of view, we are looking at any material that reduces complexity, that removes material, that ensures its recyclability and meets our current sustainability pledges, but also, really makes the use of the technology in the right way. We have technology that is ready to go, nobody will ever buy it because of the cost of it. So, there is a journey to go on from pure research, to make it commercially viable, to bringing it to the market. But believe me, we are—every industry is looking at alternative materials.

JS: I think the only thing I would add is that if we’re serious about a circular economy in plastics, then we need to design plastics for recyclability. So, we clearly need to be thinking about how we design both the plastics and the composites that the plastics are part of so that they will work in whatever recycling processes we’re looking at—one of which I described. To give you one example of a problem that I hadn’t really thought about until I came across it. Bromine is a problem in plastics because Bromine is a component in fire retardants. Well, we want our plastic to be fire retardant and no doubt, nobody thought about the recyclability issue when they started putting Bromine compounds in there. But somebody is going to have to come up with a different fire retardant that doesn’t have the same recyclability problems.

MS: Just to add one thing as well, especially for pharmaceuticals, food use, cosmetics, there are lots and lots of regulations around a lot of these products. We can’t design materials that have any risk to the consumer, and the cost of getting it wrong is so big for our business. We spend millions of pounds looking at materials to make sure that the material hits all the sustainability requirements, but also, are safe to use and make sure that they comply to regulations, not just here in the UK, but worldwide. So, there is a process to it and the material and sustainability of the material will lead to the consumer [unclear 01:05:43], but end of life, as well, is vitally important.

**AD: Thank you to you all for your comments, I’m sure that both Stefan and Natasha could come in on these points as well, there is an awful lot to consider around them and that is why we’re having 2 more webinars coming up on the 5th and the 11th of November, where we will continue to discuss the issues and complexities surrounding plastics, their use, and their disposal and what is limiting us from making the step change that I think, as consumers, we all want to see happen.**

 **Please do feel free to join us, we would encourage you to do so. I would like to thank all of our panellists today for their presentations and their comments afterwards, I think we’ve opened a can of worms here of discussion. Hopefully, you have started to see how complicated the problem is, and hence why we’ve brought together the Birmingham Plastics Network to look at every conceivable different angle of the problem, from the technical to the social, to the economic, and significantly beyond. Thank you for joining us.**

**Audio ends: [01:06:54]**