Addressing the Challenges of Microfibres Workshop Report

Virtual Workshop

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Thursday 17th December 2020

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With thanks to the speakers and discussion facilitators for their inputs

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Organised and facilitated by:
UK Microplastics Network
UK Circular Plastics Network
Knowledge Transfer Network

Workshop Overview

The workshop ‘Addressing the Challenge of Microfibres’ was held on Thursday 17th December 2020. It was co-hosted by the UK Circular Plastics Network and the UK Microplastics Network. The event was funded and enabled by KTN. The aim of the workshop was to bring together key players across academia, industry, NGOs and government, both nationally within the UK, and internationally, to discuss some of the unique challenges posed by microfibres. The presentations and discussion group topics were selected to cover a broad range of perspectives and promote discussions surrounding product design, handling of materials, prevention of fibre shedding, loss to the environment and the potential for environmental and ecological hazard posed by fibres as an environmental contaminant.

The workshop was divided into two key themes:

1) Environmental release and impact (morning session)

2) Solutions and mitigations (afternoon session)

Each of the two themed sessions consisted of three varied presentations from experts in the field to provide different perspectives on the issue, followed by breakout groups who were each given the same set discussion questions.

The purpose of this report is to provide an overview of the key outcomes of the workshop, and the proposed considerations for future research and innovation in this field, resulting from discussions had on the day. This document is not intended to provide a roadmap or concrete recommendations for next steps, but should give an overview of the main points that were raised, based on the views of those present.

This report is not comprehensive, and so not all points raised have been detailed here, but those that stimulated further discussions, were raised by multiple delegates or were considered to be the main workshop outcomes are included.

A recording of the workshop can be found here.

Session 1: Environmental Release & Impact

Presentations within this session:

Plastic Microfibres: The Journey from Washing Our Clothes to the Ocean
Dr. Imogen Napper, University of Plymouth

Microfibres in soil: effects on earthworms and their potential toxicity
Dr. Miranda Prendergast-Miller, Northumbria University

Synthetic vs. Natural microfibres – which should we be worried about?
Dr. Richard Blackburn, University of Leeds

Discussion group questions and collated responses

1. What are our key understandings in this relatively young field so far?

It was recognised across the discussion groups that while research in this field is quite young, we have sufficient evidence to show that microfibres from anthropogenic sources are widespread within the environment. What the research is lacking, however, is an understanding of the long-term consequences of this widespread distribution. For example, where will they go, how will they degrade, and what will the ecological effects be? There is evidence to show that fibres made of plastics or modified natural materials can have hazardous consequences to organisms based on entanglement or ingestion leading to gut blockage or internal damage, with further concerns around human exposure and health given our constant exposure to synthetic materials and textiles.

It is understood that fibres have the potential to be more harmful than beads due to their long gut retention time and potential to caused entanglement to organisms. Research into ecotoxicity and hazard of particulate materials (for example in microplastics research) should therefore seek to include microfibres as a material form. In general, there is a focus on plastic microfibres (microplastics), however we need to broaden our focus to include modified natural materials such as cellulose and cotton, which can also persist and have negative environmental consequences. Therefore, when talking about ‘microfibres’ we should be considering all types of material, not just plastics. It was highlighted that definitions of microfibres may vary between textile industry professionals (microfibre = fibre with a linear density less than 1 denier, i.e. 1 g/9000 m) and academics approaching the issue from an environmental perspective (microfibre = fibre < 5 mm or < 1 mm in length as per the definition of microplastics). It is critical that these differences are recognised and acknowledged in cross-sector discussions.

In order to understand ecosystem exposure to microfibres it is essential to understand and map the key sources, and the magnitude of release to the environment. While the research base is rapidly expanding, there are still significant gaps in our knowledge, for example there is a reasonable amount

of research on the abundance of microfibres within aquatic (freshwater and marine) systems, but research on fibres on land and within soils is limited. We also do not understand what are the key environmental factors influencing the transport and spread of microfibres, and how different factors will interact. Further research across all systems will be key to tracing pathways and fate of these particles within the environment. Additionally, such research is key to informing required mitigation measures and assessing the effectiveness of these.

2. Where are the knowledge gaps and why (funding/feasibility/public interest)? How can these gaps be addressed?

It was discussed that while research and funding on this topic is increasing, there are still many uncertainties. This is in part due to the complexities of using 'microfibres' as a definition, comprising a vast array of material types, shapes, uses and properties. This poses the suggestion that while we are currently looking at the issue from a variety of angles, we are still not fully understanding it.

Material variety is a key consideration. A hindrance to the academic research community is a lack of access to information on the materials and processes used for producing textiles. This in part due to insufficient cross-sector communication, but also due to commercial confidentiality when it comes to material design and manufacture. By knowing the most abundant microfibre sources and compositions (e.g. it was suggested that this might, in fact, be cotton rather than synthetic fibres), we can target solutions and mitigations to prevent or reduce the release of this specific source to the environment. Further trying to understanding degradation of fibres (e.g. breakdown into smaller pieces, or chemical decomposition) will help in determining likely long-term fate and effects of microfibres, recognising that this degradation will be significantly different depending on the environment and conditions under which the fibre resides. We do not understand well how the physical properties of fibres change when they interact with biological systems, although it is certain that these interactions occur, and indeed alter particle fate and behaviour.

It is known that particle size can play a large role it bioavailability and potential to translocate from the gut or lungs into tissues, and generally the smaller the particle, the more bioavailable it will be. However analytical challenges exist surrounding analysis of the smallest particles (< 10 µm) within real environmental samples, and standard analytical methods vary depending on the lab and available facilities. To this end, International Organization for Standardization (ISO) is developing standards and recommendations for microplastic definitions and methods (ISO/TR 21960:2020), while the British Standards Institution (BSI) has a relevant working group (PRI/89). Something that is missing are standard materials that can be used in laboratory testing to assess the efficiency of analytical techniques and toxicology. Such materials do not currently exist, making standardisation very difficult.

When considering anthropogenically modified materials such as cellulose (to produce rayon or viscose), it can be very difficult to analytically distinguish these from natural organic matter. Therefore, it can be difficult to link known toxicity and hazard (as assessed in the laboratory), to real environmental exposure. Even with targeting testing, we still have limited understanding about the short or long-term health effects on humans or ecosystems based on direct or indirect exposure. Given the demonstrated ubiquity of microfibres in indoor and outdoor environments, exposure is likely to be chronic.

One of the main challenges facing research is funding, with worthwhile research requiring several years' worth of time, budget and multidisciplinary collaboration. Such work does not come cheap and therefore funding from a variety of sources is necessary to help address the issue. It is notable that funding follows public interest, and so the majority of funding currently available is for fibres as a constituent of microplastics. However, knowing that semi-synthetic and modified natural fibres are also an environmental contaminant and may be equally harmful, funding should more broadly address the range of textile and fibre materials to enable a holistic approach to the research. The challenge may be in convincing funders that this is a field worth of research funding, where public interest and engagement is (currently) low.

3. Is there excessive focus on plastic fibres vs natural fibres?

There was widespread agreement amongst delegates that, while plastic fibres are important and research should continue, this research must extend to modified naturally-derived materials. There is a misconception amongst the public that natural fibres (e.g. cotton, bamboo fibres) are better for the environment, not considering the processing and modification of these materials. It has been shown that these are as abundant, if not more abundant, within the natural environment and that the process of modifying these fibres (e.g. addition of chemicals, changing of physical and chemical structure) can lead these materials to be as persistent and hazardous as plastic fibres. For example, modified natural fibres still contain a wide range of chemicals and dyes which can leach out of fibres and be toxic in themselves.

Alternatively, recycled plastic materials are becoming more commonplace, including clothes made from 'ocean plastics', which may indeed help to reduce one problem (litter in the environment) but does not address the issue of fibre shedding from these materials when worn or lost (releasing the collected litter back into the environment, albeit in a different form).

It was noted also on an environmentally-related note, that the processes themselves for manufacturing materials can be very environmentally damaging, using large-scale industrial processes, significant quantities of water and chemicals and with a high carbon footprint of manufacture and transportation. Any attempt to improve the environmental consequences of textile and material production and usage should not discount these wider considerations (not simply during wear or end of life).

4. Can we say which fibres are (likely to be) most harmful to ecosystems and humans, and why?

Based on existing research on other materials and particle types, we know that particle characteristics are very important in determining their hazard potential. For example, in microplastics research, there is evidence to suggest that shape of particle is important in determining its hazard potential and toxicity as fibres are more likely to entangle organisms, or lead to gut blockages than fragments or beads. Also, the shape of the particle will relate to its original or intended application, (e.g. fibres from textiles) and

therefore can influence the additive chemicals that are present and can leach out of the particles under environmental conditions. With respect to other fibre types, ample evidence exists for the toxicity of asbestos, naturally-occurring materials with the greatest hazard posed by the rigidity of the fibres themselves (as opposed to the chemical composition), thus causing inflammation or microscopic internal lacerations within the lungs once inhaled, ultimately leading to long-term lung conditions. We should apply this knowledge of other fibre types to our understanding of microfibre toxicity, where appropriate.

It can be assumed that fibres that have been anthropogenically modified are likely to be more persistent and harmful than natural unmodified particles. For example, cellulosic fibres are abundant within the natural environment in the form of plant materials, and, far from being a hazard, are often a food source. However, modified cellulose such as rayon or viscose will be environmentally persistent and contain a wide range of chemicals such as dyes and flame retardants. The health effects of these on organisms and ecosystems will vary depending on the organism and also on the route of exposure, with fibres likely to be both ingested and/or inhaled. The likelihood and duration of exposure are key in determining hazard, with extended exposure more likely to lead to harm.

We need a common language for defining hazard and harm, knowing that certain criteria need to be met to achieve these definitions. For example, in ecotoxicology research, ‘lethal’ and ‘sub-lethal’ are terms that are commonly used to define outcomes relating to death or adverse health effects. However, terms such as ‘sub-lethal’ would not commonly be used with respect to human health. Which terms refer to chronic health effects and which to acute responses, what are the agreed timescales of these, and do acute responses become chronic with extended exposure?

Knowing that we cannot manage or control all types and sources of microfibres, there are questions to be addressed with respect to which are the most crucial to address first: medium/low harm fibres released in large quantities, or high harm fibres released in low quantities?

Session 2: Solutions and mitigations

Presentations within this session:

Reducing Microplastic Fibre Emissions to Waterways: From Textiles to Water Treatment technologies
Dr. Denise Mitrano, ETH Zurich

Laundry microfibre research: identifying near-term improvements en-route to a longer-term solution
Dr. Neil Lant, Procter and Gamble

The Microfibre Consortium
Sophie Mather, The Microfibre Consortium

Discussion group questions and collated responses

1. What are the challenges facing industry in this field?

One of the key challenges is the lack of knowledge of microfibres as an environmental pollutant and a health hazard. While we understand that microfibres are widespread throughout indoor and outdoor environments, we don't understand the key sources leading to this contamination in different locations, the behaviour of fibres under different conditions, or the hazard posed by different material and particle types. This is an issue that would be best tackled at the source, to prevent the uncontrolled loss and spread of microfibres throughout the environment. It is far easier to prevent fibres reaching the environment than it is to remove them once they reach it. This is especially related to the lack of standardised analytical or test methodologies for microfibres specifically, and we may need to accept that there may be a number of methods for testing. However. all of the existing uncertainties pose a challenge to tackling this issue at source, or mitigating any damage in the most appropriate way. Research is therefore key to inform and test the development of solutions, to ensure that these are practical, effective and economical. Both research and innovation are needed to address the issue and needs to run in parallel where possible so that the research directly informs the innovation. However, the timescale of innovation is maybe longer than research and so these can be difficult to align. This therefore requires coordinated collaboration across multiple sectors and disciplines. Targeted consortia (e.g. The Microfibre Consortium) can help to ensure open discussions between organisations facing the same challenges, while standardised methods combined with accreditation for organisations might help with consistency across approaches.

Many in industry, design and manufacture might suggest it is too difficult to control at source, for example producing non-shedding textiles would be technically challenging and costly, and indeed the knowledge to do so is not yet in place. The manufacturing industry may say it's too expensive to

change their processes, but it is important that this is planned and attained nonetheless. There are so many different stakeholders that the buck is often passed – the issue is moved around the supply chain.

An issue with tackling waste materials is inconsistent approaches to waste management and recycling, even at the local scale. This might relate to the availability of recycling facilities, waste collection by local councils and the capacity of local recycling centres. To ensure clarity and wider public understanding of how materials should be handled and disposed of, this needs to be targeted and consistent. There is a big market for textile recycling and so there is no excuse for textiles to be landfilled or incinerated, however it can often be unclear to consumers what options are available to them when they no longer want to keep an item, but the product or material is still in useable or recyclable condition.

Consumer behaviour is key in managing not only waste, but the handling of materials while in use. Many people want to do the right thing, but are not sure how to enact this. Therefore, education on best practice for material and waste handling is a key step in managing fibre losses. Critically, this depends on honest and open communication from industry, refraining from greenwashing and being honest about the pros and cons of the different materials and technologies that are being developed to address the microfibres issue. Similarly, a large proportion of people want simply to do the easiest or cheapest thing (not necessarily the right thing), and therefore incentives may need to be put in place to encourage 'good behaviour'. This will require giving consumers a level of ownership over the products and the environmental outcomes, for example deposit return schemes to ensure materials are circulated back into the manufacturing and recycling system rather than passed straight to end-of-life after their use. It is important for industry to ensure that charges are not passed to consumers, for example for example if filters on washing machines need replacing.

Ultimately, the biggest challenge is cost – not feasiblity, but evidence is needed to drive change. Making large changes to design, technology and processes will be expensive and will require significant resources put into research and innovation. While some organisations may have such funding to spare, for many this will not be possible and so smaller industries may rely on larger ones to do the legwork and pass on knowledge, or may fall behind with respect to state-of-the-art technologies.

2. What do industry need to enable best use of existing/ongoing academic research (how can industry and academia work together)?

In order to make the best use of academic research, industry first needs access to such research; it is often the case that academic publications are behind paywalls and can be accessed only by paying high charges or via a subscription service to specific journals. As such, academics must be willing to openly share their results with industry. Translation of research is equally important, as research is often aimed at a specific (academic) target audience and written in such a way that it is not accessible to wider stakeholders. Ideally, research should also be shared in accessible formats such as informal reports, presentations, or personal communications.

From the other perspective, to enable research to be targeted and useful to those who can use it

practically, it would be useful for academics to be aware of industry needs before planning and implementing research, and have industry involved in designing research from the early stages. In order for this to happen, communication channels need to be open. Conferences or workshops are a good place to enable these discussions to begin, and should ideally be held regularly and be designed in such a way to encourage cross-sector discussions. While in-person events are often best for enabling informal introductions and communications, online events can attract a much wider (international) audience including people who cannot easily travel, thus do have benefits and should not be discounted even when COVID-19 restrictions lift.

Wide advertising of funding opportunities would allow multi-disciplinary cross-sector collaborations to be built to address specific industry-relevant questions. Nonetheless, industry should be also willing to put funding into the research that will enable them to innovate and test new products, especially to fill gaps where research cannot be done in-house.

Further cross-sector discussions, like this workshop, would be useful to help develop a roadmap for activities going forward and identification of funding that would help support research and innovation in this area.

3. Which seem to be the most effective mitigation methods – fabric/textile/garment design, filtration technologies (laundry), wastewater treatment, other?

The most effective mitigation for fibre loss to the environment would appear to be designing threads and textiles so that they do not shed fibres. Once fibres are lost from textiles, it can be difficult to intercept these, for example within wastewater treatment systems, and impossible to retrieve them once they are within the environment. In the case of shedding of fibres from textiles while in wear, this can be more difficult to manage again. Unfortunately, fibre shedding (also known as 'fibre fragmentation') is inevitable with the majority of textile materials, and the knowledge and capacity to prevent this shedding is not yet well-developed.

While a shift to natural materials rather than plastics may be beneficial in some senses, great care must be taken when assuming that natural is better, especially if that natural material has been chemically modified or dyed. Shifts to using different materials need to consider the life cycle of the materials in addition to the environmental and health impacts of fibres if and when shed. There were suggestions that 100% monofibre materials may be easier to manage, but in reality, these may lead to a loss of function, especially in technical textiles. Additionally, mixed materials have been shown to shed fewer fibres than monofibre textiles in some instances.

There is currently a lot of focus in the public domain surrounding washing machine filters to prevent the loss of microfibres to the wastewater system and thus the environment (for example, with ongoing petitions to the UK government campaigning for these to be made a legal requirement). While filters (and other more portable laundry aids which are commercially available to the public) can be very effective, it should be noted that probably the largest sources of microfibres to the environment are those that are released to the air during wear, in addition to those that are inadvertently lost to the environment during textile manufacturing and processing.

Consumer behaviour and perception are key in tackling this issue, as even with the best mitigation and management measures from industry, consumers will be expected to contend with altered products, greater effort (e.g. emptying filters) and potentially higher costs when buying day-to-day products or replacement parts. Additionally, it may well be consumer behaviour that is the best way to tackle many of the challenges, for example using different wash cycles or temperatures while doing laundry. Education and public engagement will therefore be crucial to ensuring the success of any new measures. People need to feel empowered to feel that what they do can make a difference, and therefore they should care, and they should try.

Despite all of this, consumers should not be made scapegoats for industry failings, and industry need to take responsibility for the products they create and the multiple ways in which they may be handled. Where possible, fundamental solutions should be taken out of consumers' hands and built into products so that they naturally are more efficient and lead to less fibre loss, regardless of how they are used. In short, multiple measures will be needed to significantly reduce the amount of microfibres released into our indoor and outdoor environments, including improved textile design, designing manufacturing processes to capture losses, laundry filtration and capture devices (both inbuilt to appliances and portable) and consumer behaviour. However more work needs to be undertaken to identify ways to reduce microfibre loss during wear or use of textiles, and to assess the effectiveness and feasibility of targeted wastewater treatment processes. Legislation may need to be put in place to ensure industry take responsibility for these actions, but would need to be carefully written to ensure that it is specific and achievable given the current uncertainties. For example, might it make sense to target a specific type of material (plastic-based fibres? Modified natural fibres?), or a specific textile use? Is there actually enough evidence at this stage to support regulation and legislation?

4. Do you know of other methods under development not discussed here already?

Discussions between experts about fibre release can tend to become very specific and technical, considering aspects like engineering, material science and chemistry. While such discussions and attention to detail are critical to addressing the fundamental issue from the bottom up (how are fibres released, and what are the specific factors and conditions leading to this?), it is essential that we do not lose sight of the bigger picture. This involves a top-down approach considering system design, supply and demand. For example, consumer choices can have a massive impact on the clothing industry, with the potential to change manufacture volumes and the way in which new garments are made and disposed of. Sustainability is high on the public agenda, with recycled, organic and fairly traded materials now a priority for many consumers. These consumer demands help to drive positive change towards a more sustainable industry. Nonetheless, 'fast fashion' plays a significant role in global manufacture and economy which needs further addressing. Consumers need to be continually encouraged towards higher quality, lower quantity purchases where possible, being made aware not only of ethical and environmental issues surrounding production, but also the environmental issues related to garment wear and disposal.

Manufacturers have a responsibility to ensure a reduced environmental impact as a result of their processes or, importantly, end-of-life of their products. Products should be designed with end-of-life in mind for easy reuse or recycling, and accessible facilities need to be in place for the system to work. Additionally, yarn thickness, durability and textile weave all need to be considered as factors that could affect fibre fragmentation and release.

Conclusion

This workshop was successful in bringing those together that are focused on gaining insight and information about the levels of possible impact that microfibres fugitive in the environment are, and may be, having on the natural world, in addition to developing innovative technical and legislative solutions to the problem. The majority of the speakers and contributors were UK based and disseminating the findings to a wider cohort would be advisable. Nonetheless, holding the workshop online enabled the attendance of some delegates from overseas who may not otherwise have been able to join the discussion.

There are some unique challenges posed by microfibres and it is clear that improving product design, handling of materials, prevention of fibre shedding and loss to the environment are key activities we need to support going forward. There is a disproportionate focus on synthetic microfibres, however it should be noted that it isn't necessarily plastics that are the major contributors to microfibre volumes, with modified cotton and cellulose highly prevalent within the environment.

The UK Microplastics Network and UK Circular Plastics Network will work together to keep the academic and relevant microfibre communities updated of any support for projects leading to less fibre contamination entering the environment. Those interested to stay updated and join further relevant workshops are encouraged to join the UK Circular Plastics Network and the UKCPN collaboration platform.

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