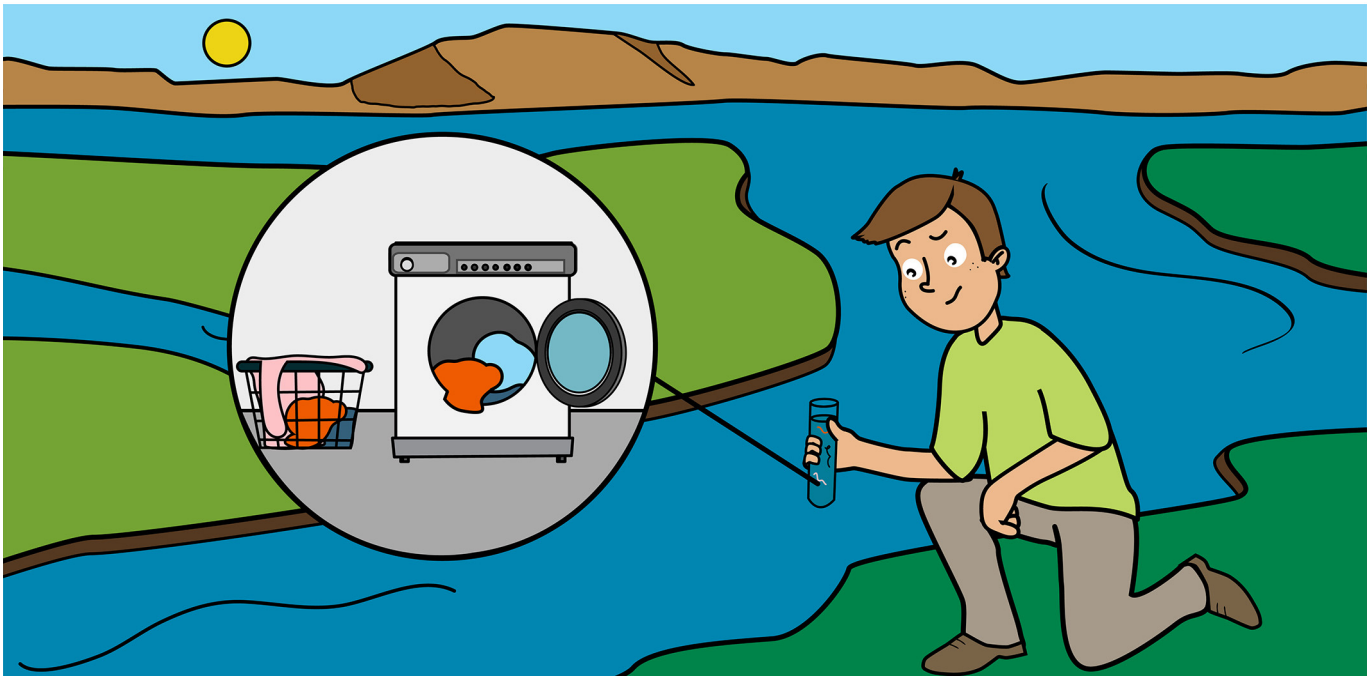
frontiers FOR YOUNG MINDS

EARTH AND ITS RESOURCES
Published: 25 May 2022
doi: 10.3389/frym.2022.743943



FLUFFY RIVERS: HOW OUR CLOTHES CAN HARM RIVERS AND THE OCEANS

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YOUNG REVIEWERS:

CHERYL
AGE: 9

FARAH
AGE: 14

HAYTAM
AGE: 13

Microplastics are one of the most well-known types of environmental pollution. A microplastic is any piece of plastic smaller than 5 mm (about the size of one of the circles on top of a Lego® block). Microplastics come in a variety of shapes and they can be eaten by even the smallest animals, blocking their stomachs and intestines. Many of the clothes that we wear are made from microplastic fibers. These fibers are released from our clothes when we wear and wash them, and they can eventually end up in the environment. We collected water samples from three rivers in the UK over 12 months, to see if they contained microplastic fibers. All the rivers contained

clothing fibers, but most of the fibers were not made from plastics. Natural fibers made from materials like cotton (from plants) and wool (from sheep) were much more common than plastic fibers.

PRICE

AGE: 14

PROVIDENCE

AGE: 10

RIVERS ARE NATURE'S HIGHWAYS

From the tops of mountains to the sea, rivers shape the landscapes that they flow through. Rivers are very important to life on Earth, and they are also really useful to humans. For example, because rivers flow from the land to the sea, one of the ways people use them is to move pollution away from cities and farmland.

Pollution includes all the harmful chemicals and particles that end up in the environment because of people. Plastic is one type of pollution, and it enters rivers when it is not thrown away properly. **Microplastics** are any pieces of plastic smaller than 5 mm in size. Once plastic pollution enters a river, it is very hard to get it out. Most of the plastic and microplastic pollution in rivers will end up in the oceans. Because of this, scientists are very interested in making sure plastic in rivers is kept to a minimum.

MICROPLASTICS

A small piece of plastic no larger than 5 mm in any dimension.

Rivers and oceans with plastic in them are unhealthy. Plastic and microplastic pollution can harm wildlife in many ways. Microplastic particles can be accidentally eaten by animals, and these particles are tiny enough that they can be eaten by some of the smallest animals in an environment. Once eaten, plastic and microplastic particles can block animals' stomachs, causing them to starve. Plastics can also release harmful chemicals into the environment or into the stomachs of animals that have eaten them. Many of the microplastics in the environment are clothing **fibers** made from plastic materials, such as **polyester** and **nylon** [1]. If you look closely, you can often see these fibers on the clothes you wear. They look like pieces of fluff sticking out from your t-shirts, trousers, or jumpers.

FIBER

A single strand of material that is longer than it is wide.

POLYESTER

A type of plastic that can be made into fibers and used to make clothing.

NYLON

Another type of plastic that can be made into fibers and used to make clothing.

HOW IS THE FLUFF GETTING INTO RIVERS?

The clothes that we wear are made from a lot of individual fibers. These fibers fall off our clothes all the time. Luckily, there are so many fibers in each piece of clothing that our clothes do not fall apart when this happens. Many of the fibers that our clothes lose break off when we wear them. You may have seen little balls of fluff on your clothes that you can pull off. These balls of fluff are made from groups of individual fibers. When you take off a wooly jumper, you might also see lots of fiber particles in the air around you. These will be fibers from the jumper. The fibers that come off your clothing can float around in the air until they eventually land. They may land directly in a river or lake. Or they may land on the pavement, or a road, or a field, and be blown into a river or washed in when it rains.

Clothes washing is another major source of fibers in rivers. In some parts of the world, people do not use washing machines but instead wash their clothes directly in lakes and rivers. Any fibers that come off clothes washed this way go straight into the lake or river. When clothes are washed in a washing machine, thousands of fibers break away from clothing in every washing machine cycle. These fibers go down the drain and end up in **wastewater treatment plants** (**WWTPs**) (Figure 1) [1].

WASTEWATER TREATMENT PLANT (WWTPS)

A place where wastewater from homes, businesses, and roads is sent, through sewer systems, to be treated. Treatment cleans the water before it is released into the environment.

Figure 1

Clothing fibers are lost from clothes when they are washed. Sewers transport the used water containing these fibers to WWTPs, which remove many of the fibers, but not all. Fibers that are not removed are released into the environment in the treated effluent from WWTPs.

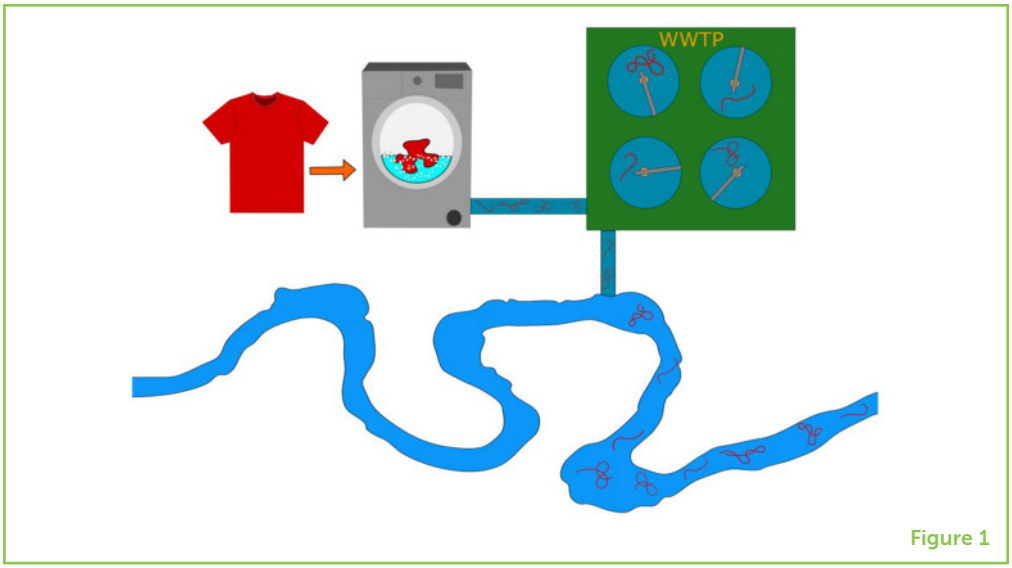

Figure 1

WWTPs remove many pollutants using various processes. One of these processes involves large tanks that store wastewater. In these tanks, particles are removed based on their density. Dense particles sink to the bottom to form something called **sludge**. Some fibers from washing machines will sink into this sludge. Once all the other treatment processes are complete, the cleaner water (called the **effluent**) is then sent to rivers, lakes, and the sea. But not all fibers sink. While WWTPs do a very good job of removing the fibers from wastewater, there are so many fibers that a lot still manage to pass through, entering rivers in the effluent (Figure 1) [2].

SLUDGE

The solid material removed as part of wastewater treatment processes to produce the cleanest effluent.

EFFLUENT

The cleaner water that is released from WWTPs into the environment after treatment.

It is not only fibers in treated wastewater effluent that can find their way into rivers. A lot of the sludge made in wastewater treatment plants is spread on farm fields because it contains nutrients that help plants grow. This means that many pollutants, including fibers, are also spread onto fields. When it rains, these fibers can be washed from fields into nearby rivers, lakes, and the sea [2].

Finally, the making of clothing is a significant source of fibers in the environment. Clothes factories produce a lot of waste and wastewater [3]. In some parts of the world, this wastewater is sent to WWTPs, but in some places it is released directly into rivers.

HOW MUCH FLUFF IS THERE IN RIVERS AND OCEANS?

It is really difficult to answer the question of how much fluff is in Earth's rivers and oceans—the truth is, no one knows. We do not even know how many fibers come off our clothing when we wash it. Each time a piece of clothing is washed, the number of fibers lost can be a few 100 or a few million [1], and not all of these fibers end up in rivers or oceans.

Our group of environmental scientists collected water samples from the River Trent, UK, and from two of the rivers that flow into it, the River Leen and River Soar. We sampled 10 sites across these rivers 13 times over the course of 1 year. Clothing fibers were found at every site, even the sites near the sources of the rivers [4]. These fibers could have come from the air, from WWTPs, or from agricultural fields that used sludge to fertilize soils.

Though plastic fibers like polyester and nylon are very common in the environment, most of the fibers in our samples were made from non-plastic materials, such as wool and cotton (Figure 2). Across all the river samples collected, 89% of the fibers were made from non-plastic materials.

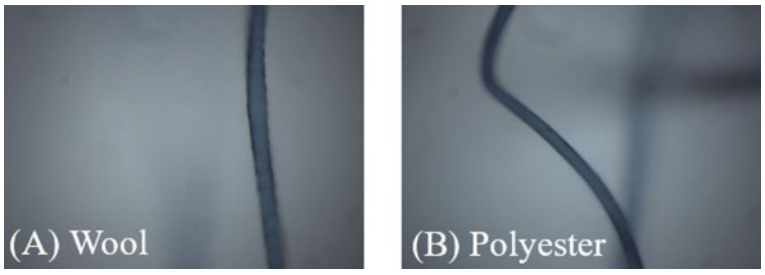

Figure 2

Figure 2

(A) A wool fiber from a sheep, and **(B)** a plastic fiber made from polyester, as seen under the microscope. Despite being made from different materials, these fibers are very similar in shape.

We found that the number of fibers at each site varied a lot throughout the year. Sometimes we did not find any fibers in our samples, but at other times our samples indicated that hundreds of millions of fibers could be flowing down the rivers each day. This makes it hard to estimate the number of fibers that are in rivers.

With possibly millions of fibers being lost each time we use the washing machine, it is important to understand the numbers of fibers, both plastic and non-plastic, in water environments, and the impacts these fibers have on these environments. Most research exploring fibers in the environment has looked at plastic fibers. Non-plastic fibers in the environment have not been studied as much, but we and others have found that non-plastic fibers are much more common than plastic fibers in oceans and even in penguin poo [4–6]. This research tells us

that scientists now need to find out how harmful non-plastic fibers are in the environment.

WHY DOES THIS MATTER?

Just like microplastic fibers, non-plastic fibers can remain in the environment for a long time. They can be eaten by many animals, including microscopic aquatic animals called **zooplankton**, and fish (Figure 3). These animals cannot digest plastic or non-plastic fibers, and instead these fibers can become tangled with anything else that has been ingested and may block the guts of these animals. If an animal that has eaten clothing fibers is eaten by another animal, these fibers then move up the food web.

ZOOPLANKTON

Aquatic organisms that are often small and near the bottom of the food chain.

Figure 3

Fibers in the environment can be eaten by small animals called zooplankton, which are then eaten by predators like fish. Once eaten, these fibers can block the animals' digestive systems and may release harmful chemicals into the animals' bodies.

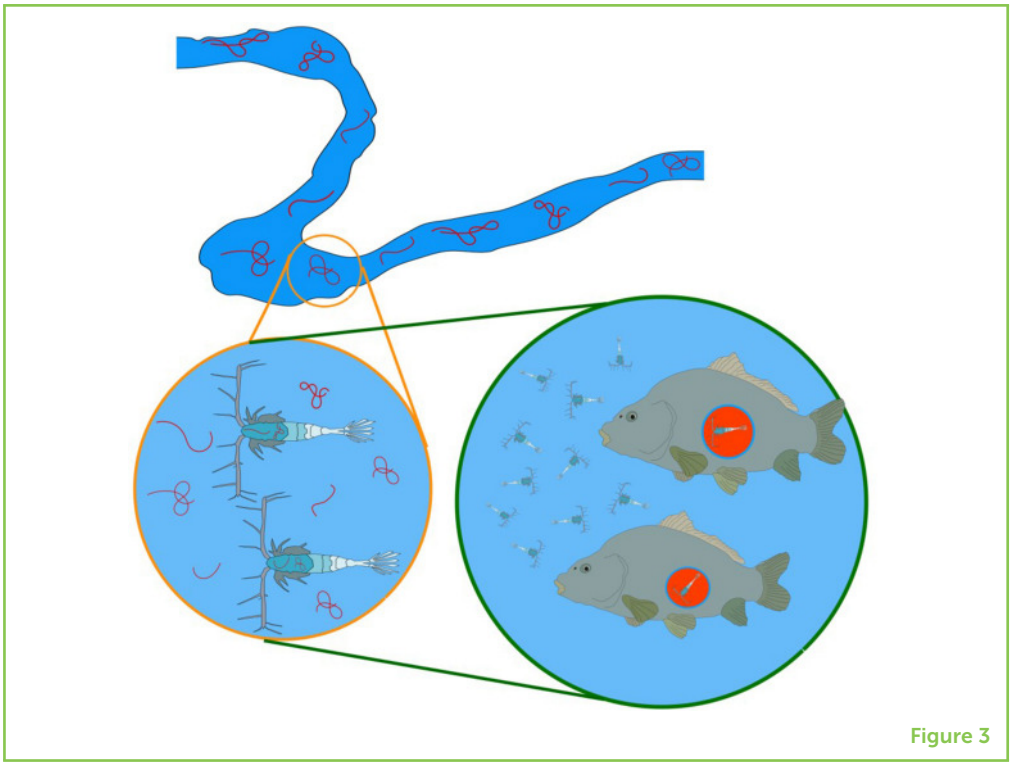

Figure 3

Like plastic fibers, non-plastic fibers can also carry harmful chemicals, like the dyes that make your clothes colorful. Fibers can release these chemicals, some of which can be poisonous to animals.

WHAT CAN BE DONE TO STOP OUR RIVERS BECOMING FLUFFY?

Clothes are an essential part of our lives, so it might seem impossible to stop clothing fibers from getting into rivers. We cannot stop wearing clothes, but we can buy clothes less often, buy second-hand clothes, and take good care of the clothes that we do own. These actions will reduce the number of fibers released into the environment and

could help to minimize the problem of fibers in rivers, oceans, and animals' digestive systems. The clothing industry can also help, by making clothes that will last longer. Governments can help by making sure the clothing industry does what it can to protect the environment [7]. Clothing fibers are just one of many types of pollution in the environment. They may not be the most harmful, but by simply changing our behavior, this is one of the easiest forms of pollution to reduce!

ACKNOWLEDGMENTS

We would like to thank the young minds that helped improve the draft versions of this manuscript, and the Natural Environment Research Group in Nottingham Trent University's School of Animal, Rural and Environmental Science for their comments on this manuscript prior to submission.

ORIGINAL SOURCE ARTICLE

Stanton, T., Johnson, M., Nathanail, P., MacNaughtan, W. and Gomes, R. L., 2019. Freshwater and airborne textile fibre populations are dominated by 'natural', not microplastic, fibres. *Sci. Total Environ.* 666:377–89. doi: 10.1016/j.scitotenv.2019.02.278

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SUBMITTED: 19 July 2021; **ACCEPTED:** 26 April 2022;
PUBLISHED ONLINE: 25 May 2022.

EDITOR: Varun Vohra, The University of Electro-Communications, Japan

SCIENCE MENTORS: Nordin Ben Seddik and Florence Barbara Awino

CITATION: Stanton T, Johnson M, Gomes RL, Nathanail P, MacNaughtan W and Kay P (2022) Fluffy Rivers: How Our Clothes Can Harm Rivers and The Oceans. Front. Young Minds 10:743943. doi: 10.3389/frym.2022.743943

CONFLICT OF INTEREST: PN was employed by Land Quality Management Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

CHERYL, AGE: 9
Hi, I am Cheryl. I have a cat named Delilah and 2 little sisters called Tanya and Alice. I live in a small city of Canberra. I am sometimes pretty shy and sometimes pretty cheeky. I absolutely love ice-cream especially "Cookies 'n' cream" Love you all.

FARAH, AGE: 14
My name is Farah, I am 14 years old, my school level is the first year of high school, my favorite subjects are physics and mathematics, in my free time I read books and surfing the net. As a social person, I like discussions on scientific phenomena and discoveries, my dream is to become an engineer.

HAYTAM, AGE: 13
My name is Haytam, I am 13 years old. My academic level is the third preparatory. My favorite subjects are: maths, physics, science and English. My hobbies are: swimming, drawing and reading. I practiced taekwondo for 2 years. I speak English and French

fluently. I have previously participated in the arab reading challenge and I participated in the math Olympiad too. My dream is to become a doctor or a vet.

PRICE, AGE: 14

Price loves making up stories and has also written a book (Ms. Wasteson and the waste empire). She enjoys gymnastics, athletics, volleyball, and basketball. She is brave and bouncy. Price also enjoys quality time with family and is very creative. At her school, she is part of a "green team" that works to protect the environment. She likes debating and has a passion to study and become an activist against social injustices.

PROVIDENCE, AGE: 10

Providence is the youngest amongst her three sisters. She is playful and bouncy. Providence is curious, talkative, and likes asking many funny questions, that leaves others laughing. She loves making new friends and traveling. Providence loves science experiments. During this process, she may destroy, repair or recycle some household items. As part of this adventure, Providence repaired a spoilt speaker. But after weeks of action, she modeled the speaker wires into skipping ropes. She is passionate about music and sports including volleyball.

AUTHORS

THOMAS STANTON

Tom is a freshwater scientist at Loughborough University whose research focusses on the way society pollutes the environment. He is particularly interested in pollution from plastic and non-plastic litter, with a specialism in textile fibers. Tom's work looks at pollution in the present day and in lake sediments that lock up signals of human activity from the past. He also enjoys sharing his work with non-scientists and explore how his research can help people and organizations make informed decisions about environmental actions. *t.stanton@lboro.ac.uk

MATTHEW JOHNSON

Matt studies rivers at the University of Nottingham, in the School of Geography. His research focuses on how living organisms survive in the powerful and changeable environment that rivers provide. He is also interested in how river habitats are altered by people due to pollution, management and climate change. He regularly works with government agencies, companies, and charities that manage rivers to help create better habitat for aquatic plants and animals.

RACHEL LOUISE GOMES

Rachel is a Professor of Water and Resource Processing at the University of Nottingham and leads *Water Works*, the University's Interdisciplinary Research Cluster. She has a particular love for wastewater treatment, and how best to remove pollutants to improve water quality and support water reuse. Rachel's research allows her to travel the world working with companies, charities and Governments and she was recently an invited expert on the United Nations Environment Programme Advisory Group on Plastic Litter and Microplastics.

PAUL NATHANAIL

Paul is a geologist who has combined research, training and consultancy for the past 30+ years. He has been a University Professor, managing director of a small consultancy and is now the Technical Services Leader for environmental solutions across Europe, Middle East and Africa for GHD—a global professional services company. Throughout, Paul has been able to apply his passion for his subject to his work and to developing his colleagues.

WILLIAM MACNAUGHTAN

Bill is a recently retired food scientist from the University of Nottingham department of Food, Nutrition and Dietetics. He specialized in making a variety of measurements on foods and raw ingredients. These universal measurements were often first made in areas different to food, such as polymers and plastics. Due to this, they are well suited to the detection and identification of impurities and pollutants in our natural environment, as well as our food.

PAUL KAY

Paul is Professor of Water Science at the University of Leeds and Associate Director of Water@Leeds, one of the biggest water research centers in the world. He is interested in how human activity impacts the water environment and works mainly on water pollution. This has focused largely on previously unstudied contaminants, such as plastics, and how we can manage our activities better to reduce environmental impacts.