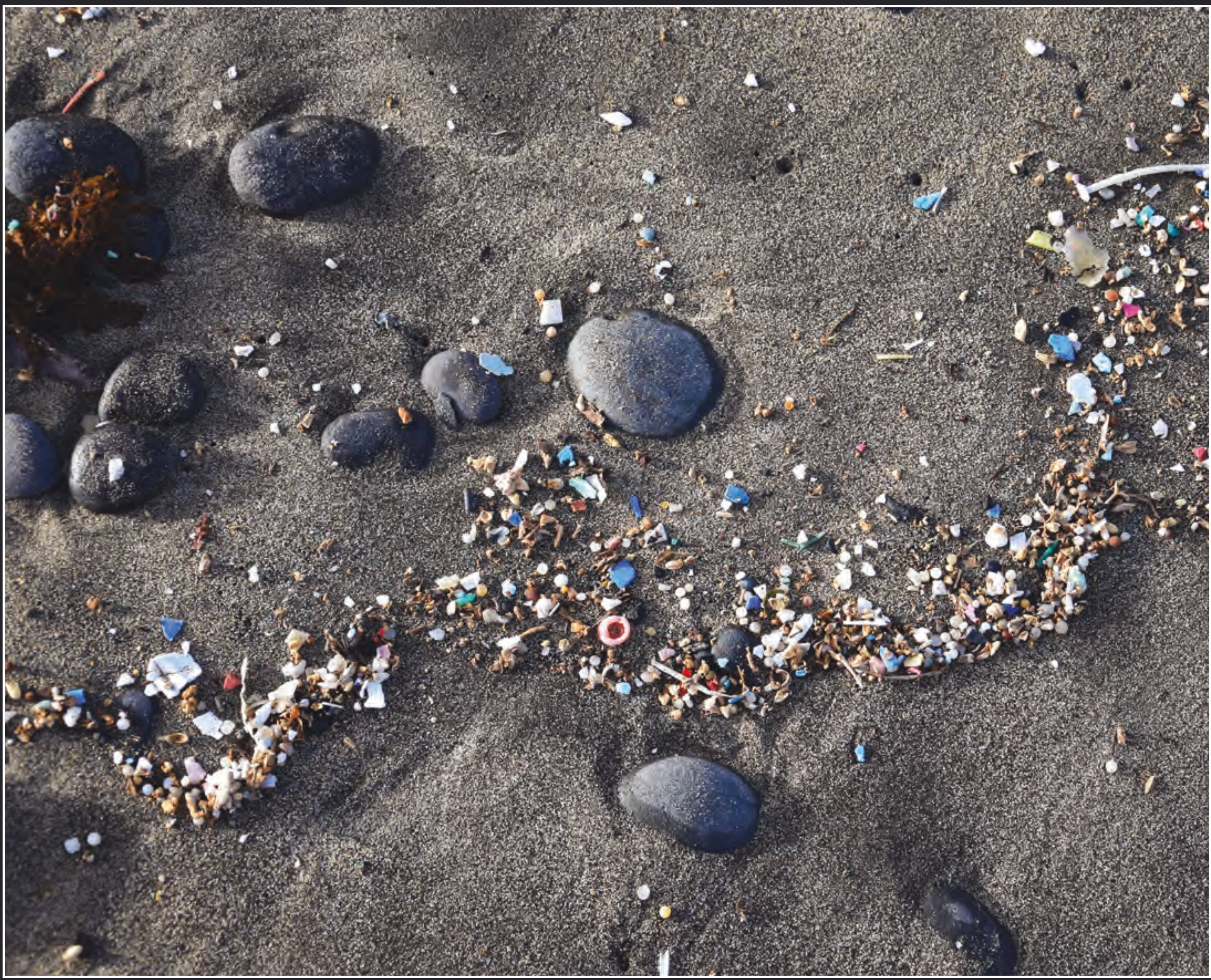
DETECTING MICROPLASTICS IN A GREAT LAKES WATERSHED WITH UNDERGRADUATE STUDENTS

DR JULIE PELLER



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TRILLIONS OF TINY BITS OF PLASTIC – KNOWN AS MICROPLASTICS – CONTAMINATE OUR ENVIRONMENT. AMONG THESE ARE MICROFIBRES – VERY SMALL THREAD-SHAPED PLASTICS – ROUTINELY RELEASED FROM EVERYDAY WASHING OF SYNTHETIC FABRICS. THE REALITY IS THAT MANY OF THESE PLASTIC PARTICLES CONTINUE TO END UP IN RIVERS AND OCEANS, AND POSE A DANGER TO AQUATIC ORGANISMS. WITH THE HELP OF UNDERGRADUATE RESEARCH STUDENTS, **DR JULIE PELLER**, FROM **VALPARAISO UNIVERSITY** IN INDIANA, USA, IS ASSESSING THE MICROFIBRE POLLUTION IN SURFACE WATERS, WITH A FOCUS ON THE GREAT LAKES

We are surrounded by plastic: plastic bags, water bottles, takeaway containers, chocolate wrappers, the list is endless. Unfortunately, many people ignore the massive waste problems associated with plastic, especially single-use plastic, and much of our plastic waste breaks down into microplastics. Now, microplastic pollutants seem to be present everywhere, even in remote areas of our planet like the Arctic and Antarctic.

Knowing they pose a serious threat to many aquatic species, Dr Julie Peller, from Valparaiso University in Indiana in the US, has been assessing the levels of microplastics, in particular microfibres, in a Lake Michigan watershed and other Great Lakes ecosystems. Undergraduate research students also contribute to this project, not only to increase awareness about the importance of scientific research but also to contribute to the pool of knowledge as the magnitude of the problem grows daily. As Julie warns, "The negative effects will be exasperated if we do not address the problem."

WHY IS PLASTIC SUCH A BIG ISSUE?

Plastic is not biodegradable. Unfortunately, instead of being recycled, most of it ends up in a landfill or in the environment, where

TALK LIKE A CHEMIST

MICROPLASTICS – very small pieces of plastic that pollute the environment. These include all types of plastic that are smaller than 5 mm

MICROFIBRES – fibres made of either natural or synthetic materials that are less than 5 mm in length. Synthetic microfibres are a category of microplastics

BIODEGRADABLE – refers to the breakdown of matter, typically done by microorganisms, such as bacteria and fungi, present in the soil or water

WASTEWATER TREATMENT PLANT – a facility that uses various processes, including physical, chemical and biological, to treat wastewater and remove pollutants

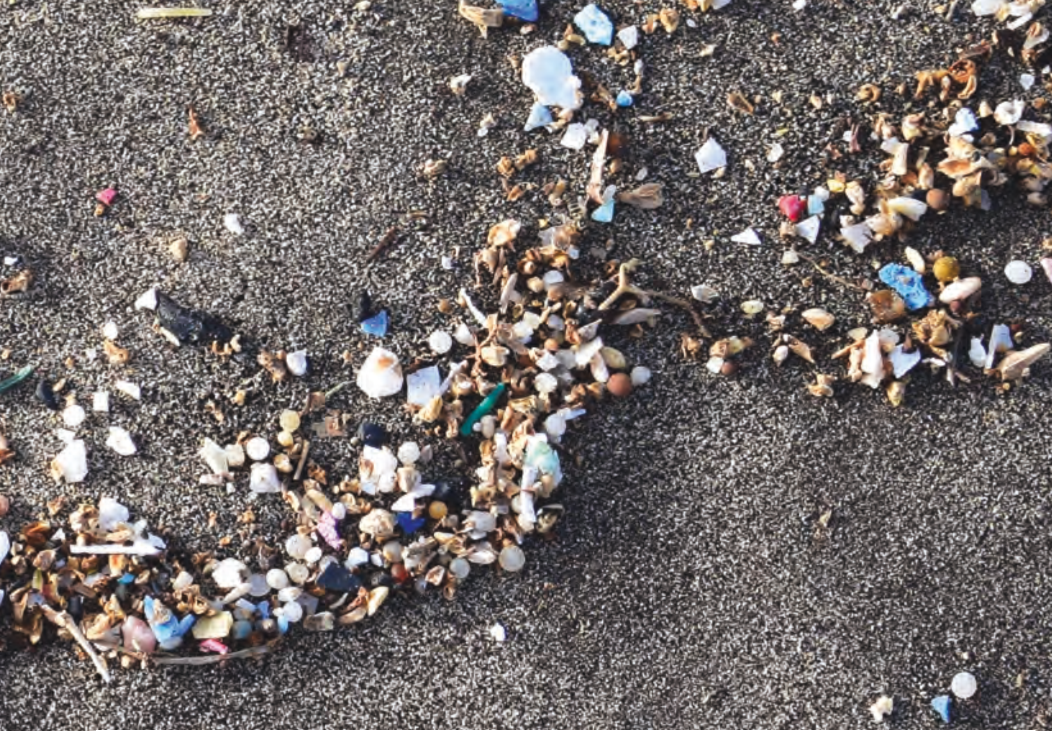
CHEMICAL OXIDATION – a type of chemical reaction involving oxygen or an oxygen-containing substance that increases the amount of oxygen or oxidation state of another substance

FENTON'S REAGENT – a solution used to break down many organic compounds via chemical oxidation

HYDROGEN PEROXIDE – a chemical compound with the formula H_2O_2

ORGANIC MATTER – refers to carbon-based living or dead animal and plant material. This includes living plants and animals, remains at various stages of decomposition, as well as microorganisms and their excretions

POLLUTANT – any substance, including certain chemicals and waste products, that is detrimental to the environment. It can be anything that causes pollution, from toxic gases in the air to microplastics in the water



sunlight and other weathering processes break it down into tiny particles called microplastics. Scientists know that these particles can be extremely dangerous, with studies showing how they stunt growth, disrupt reproduction and alter feeding habits of fish and other aquatic species.

Microplastics are also shed from clothes made from synthetic fabrics, such as polyester, when they are washed. Standard washing machines were never manufactured to remove all these microfibres and they end up in our wastewater. Most of these microfibres can be removed in wastewater treatment plants, but a small percentage remains in the water and flows to natural surface waters, including the oceans.

Previous studies looking at the microplastic content in Lake Michigan (part of the Great Lakes in the USA) motivated Julie to test for the presence of microplastics and microfibres in surface waters flowing into Lake Michigan. "The water in local streams and creeks flows into Lake Michigan, and we were interested in determining the extent of microplastics contamination in both the water and sediment," says Julie.

AN EXPERIMENT AIMED AT UNDERGRADUATE STUDENTS

The twist in the research was that it was adjusted to be part of first-year undergraduate students' chemistry curriculum. Julie and her colleagues wanted to engage these students in active scientific research by exploring the current worldwide problem of microplastics contamination. Over the course of a three-week experiment, students collect soil samples from two locations, one near a local wastewater treatment plant. Using different lab techniques, they remove particles larger than 5 microns. The next step involves chemical oxidation to reduce the natural organic matter, leaving the plastics and some inorganics behind. This is done by exposing the samples to the Fenton reagent, a solution of hydrogen peroxide (H_2O_2) and iron (II) chloride. The mixture is heated until it stops foaming, which is an indication that most of the reactive organic matter is chemically broken down. After this mixture is filtered, students count microfibres present in each sample using a microscope.

From the research project, the amount of microfibres found in the samples collected closer to the wastewater treatment plant, and the samples collected further away (and presumably not affected by household sewage) were similar. For Julie, this indicates that the water from the wastewater treatment plant is not the only source for the high amount of microfibres in this area of the Lake Michigan watershed. "The data showed that a significant amount of synthetic microfibres are discharged daily to Lake Michigan," says Julie. "We analysed just one main tributary and expect that it is somewhat representative of others".

The big question now is how to reduce these pollutants and minimise their adverse effects. Scientists are still learning about the consequences of these contaminants in our environment, but this research needs to be done with a great deal of urgency. Our world is drowning in plastic with more and more being added every day.

GOOD NEWS FOR FUTURE RESEARCH

Julie believes that recent studies of Lake Michigan green algae with microfibres may offer insight into ways to battle against this type of plastic. Certain aquatic plants are able to trap and cling to microplastics. If researchers learn more about these natural mechanisms, they may be able to develop ways to reduce the discharge of microplastics into aquatic environments.

DR JULIE PELLER

Professor of Chemistry, Department of Chemistry, Valparaiso University, Indiana, USA

FIELD OF RESEARCH

Environmental Chemistry

RESEARCH PROJECT

Tracking the distribution of microfibre pollution in a southern Lake Michigan watershed through the analysis of water, sediment and air.

FUNDER

US National Science Foundation

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In addition to the valuable data collected from microplastics research, Julie's project also helps undergraduate students become more aware of how scientific research is used to solve every-day problems. As a bonus, this work made most participants more conscious about the dangers of plastic pollution and consider reducing the amount of plastic they use in their life. This is ideal preparation to enable these students to lead citizen science projects in the future.

Julie and her team at Valparaiso University are keen to offer public outreach programmes for schools and young people, which may be a good way to find out more about becoming a chemist. Choosing a career in chemistry can be extremely rewarding. Many chemists work in a lab, but there is so much more they can do. Chemists can develop new textiles for the latest fashion trends or even play a key role in criminal investigations. It is fascinating to think where chemistry could take you!

ABOUT CHEMISTRY

WHAT IS CHEMISTRY?

Chemistry is everywhere. Everything you eat, smell and touch involves chemicals. It is the makeup of materials, including all the complex chemical reactions that happen in your body. In everyday life, you can find chemistry when you cook, make a cup of tea or even when you pick new trainers to go running.

In academic terms, chemistry is the science that deals with the properties and structure of different substances, as well as the transformations they can have.

HOW CAN CHEMISTRY HELP FIGHT POLLUTION?

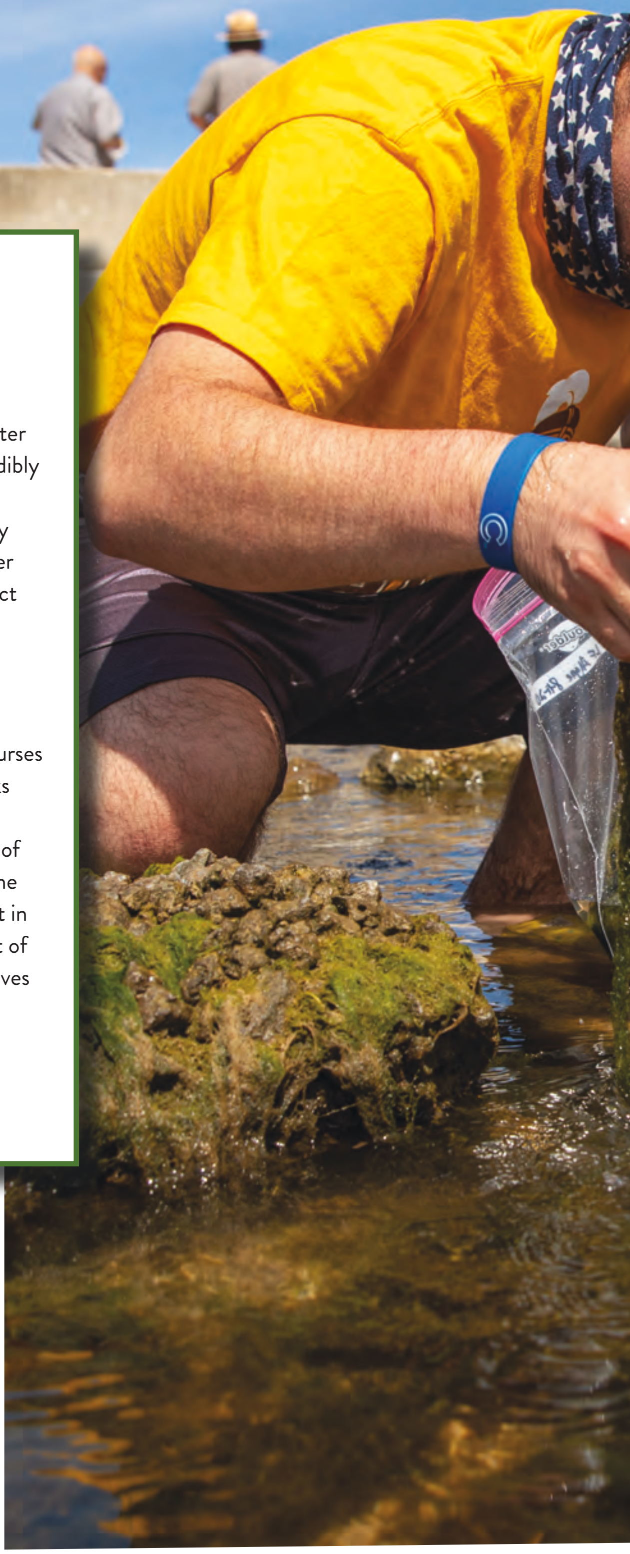
Chemistry can be very useful in the fight against pollution. It can help scientists understand how pollutants interact with animals and plants and how they can be harmful. Chemistry is also key to creating new ways to reduce pollution, including developing cleaner fuels or fitting vehicles and industries with pollution control devices.

WHY IS WATER QUALITY SO IMPORTANT?

Monitoring and investigating aspects of water quality and environmental health are incredibly important. After all, living organisms rely on healthy fresh water for survival. It is very rewarding to contribute knowledge on water quality and environmental issues that impact people around the globe.

WHY INVOLVE STUDENTS IN THIS PROJECT?

Integrating research projects in science courses challenges students to go beyond textbooks and think about the key questions that we need to answer. Students get a better idea of how research is conducted, learn beyond the surface level and often find greater interest in topics. Many of these topics should be part of science curriculum since they impact our lives in critical ways.



HOW TO BECOME A CHEMIST

- A good place to discover the wide range of career options in the chemical sciences is the American Chemical Society: **https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers.html**
- Typical employers include health services, research institutes, military and law enforcement, industry and schools.
- In the UK, you could work towards chartered status, including Chartered Chemist (CChem) and Chartered Scientist (CSci).
- According to the American Chemistry Council, the average annual salary of a US chemical industry employee is $87,000.

PATHWAY FROM SCHOOL TO CHEMISTRY

To become a chemist, you usually need a degree in either pure chemistry or in a specific field, such as analytical chemistry or biochemistry. Some employers may favour a relevant postgraduate qualification.

You may also be able to get into this career through a laboratory scientist higher apprenticeship or start as a laboratory technician and train while working by doing a relevant qualification.

The education website for the Royal Society of Chemistry is a good resource if you are considering a future as a chemist: **https://edu.rsc.org/future-in-chemistry/**

JULIE'S TOP TIPS FOR STUDENTS

01 Follow your interests.

02 Work with integrity.

03 Take advantage of opportunities.

04 Always take pride in your pursuits!

Undergraduate research student, Eddie Kostelnik, collecting algae from Lake Michigan near the shoreline in Portage, Indiana, USA.

HOW DID JULIE BECOME A CHEMIST?

WHAT WERE YOUR INTERESTS AS A CHILD?

I mainly pursued my interest in music and took piano lessons throughout my younger years. I was admitted to one of the top music schools in the US when I was 18 but began to recognise my interest in science and in the chemistry courses I took during my freshman year. Obviously, I transitioned to science, but still play piano almost daily.

WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

I cannot pinpoint any one single person who inspired me to become a scientist but attribute my path to teachers and professors who taught and encouraged me.

WHAT ATTRIBUTES HAVE MADE YOU A SUCCESSFUL SCIENTIST?

I love to learn, to investigate and to solve problems. I also enjoy sharing these experiences with friends, collaborators, students, colleagues and community. I believe that when you enjoy getting up in the morning and pursuing your interests, you can accomplish a great deal.

HOW DO YOU OVERCOME OBSTACLES IN YOUR WORK?

Science requires supplies and equipment, which can be costly and challenging. It is not always possible to have the resources that you want to carry out research, and this is often a large obstacle. Also, as a university professor, much of my time is devoted to teaching and service, in addition to research. These challenges are met with resourcefulness and effective time management, especially when you are interested in making progress in your work.

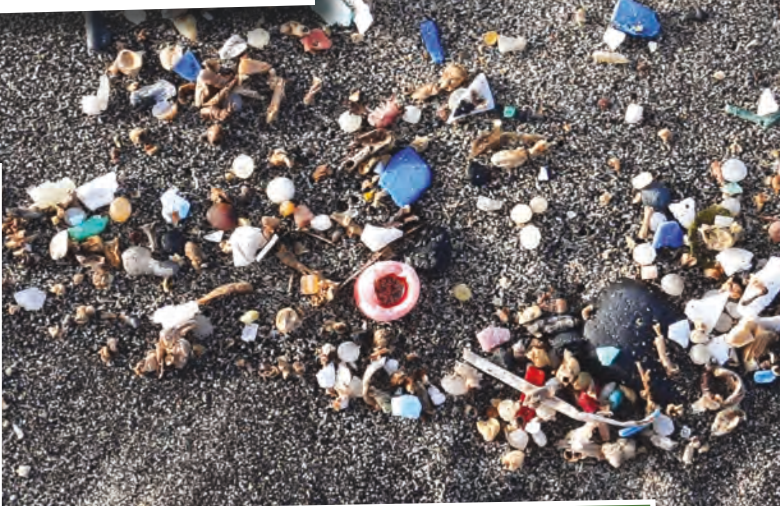
WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

I would say that I feel most proud when my students offer sincere gratitude for the experiences and education that I have provided for them. I also feel that I have contributed to science when I publish new findings with my collaborators.

WHAT WOULD BE YOUR 'DREAM' RESEARCH PROJECT TO WORK ON?

I am grateful that I am able to pursue my research interests thanks to many great institutions, collaborators, colleagues and students. I aspire to create greater awareness of critical environmental problems, such as plastic waste. I find that once people are aware of the problems, they are more inclined to participate in the solutions.

CHEMISTRY WITH DR JULIE PELLER



TALKING POINTS

KNOWLEDGE

1. What are microplastics and where do they come from?
2. What are synthetic microfibres and where do they come from?

COMPREHENSION

3. How do microplastics end up in the ocean?
4. Can you explain how microplastics can be dangerous to aquatic species?

ANALYSIS

5. Julie's results showed no significant differences between the two types of locations analysed: one above a wastewater treatment plant (not affected by the discharge) and one downstream from the WWTP discharge. Did you find these results surprising? Why or why not?

EVALUATION

6. Can you suggest a few practical ways that everybody can help to reduce plastic pollution?
7. To what extent do you think a ban on single-use plastic items, such as the plastic straw ban, will help reduce plastic pollution?

CREATIVITY

8. What other legislation to control pollution would you suggest?

MORE RESOURCES

GENERAL CHEMISTRY

There is so much to learn about chemistry. Here are two useful websites for you to find out more:

- Royal Society of chemistry: **https://www.rsc.org/**
- ACS Chemistry for life: **https://www.acs.org/content/acs/en.html**

PLASTIC POLLUTION

Find out about brilliant organisations raising awareness of this global issue:

- Kids Against Plastic: **https://www.kidsagainstplastic.co.uk/**
- Surfers Against Sewage: **https://www.sas.org.uk/our-work/plastic-pollution/plastic-pollution-facts-figures/**
- Plastic Pollution Coalition: **www.plasticpollutioncoalition.org**

ACTIVITIES YOU CAN DO AT HOME OR IN THE CLASSROOM

ACTIVITY 1 - SPOTTING MICROPLASTICS

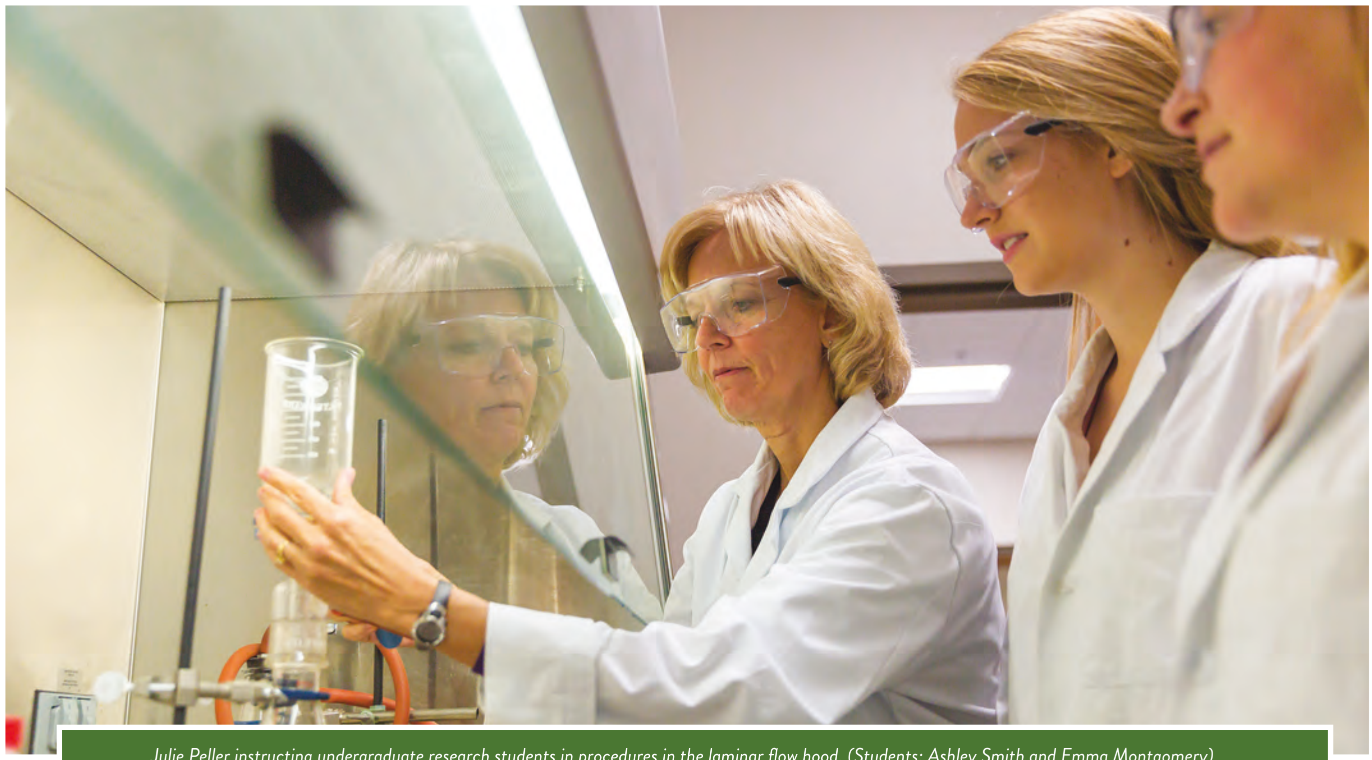
In a similar way to what Julie and her team did, collect samples from a local beach or river. Sadly, most beaches around the world are already contaminated, so there is a high probability that you are going to find at least some microplastics.

- Analyse the sample with the naked eye and then using magnifying lenses.
- Make a note of what you can find.
- Think about what and where these specific fragments may have originated from.
- Discuss and reflect on the hazards of microplastics and the importance of preventing water pollution.

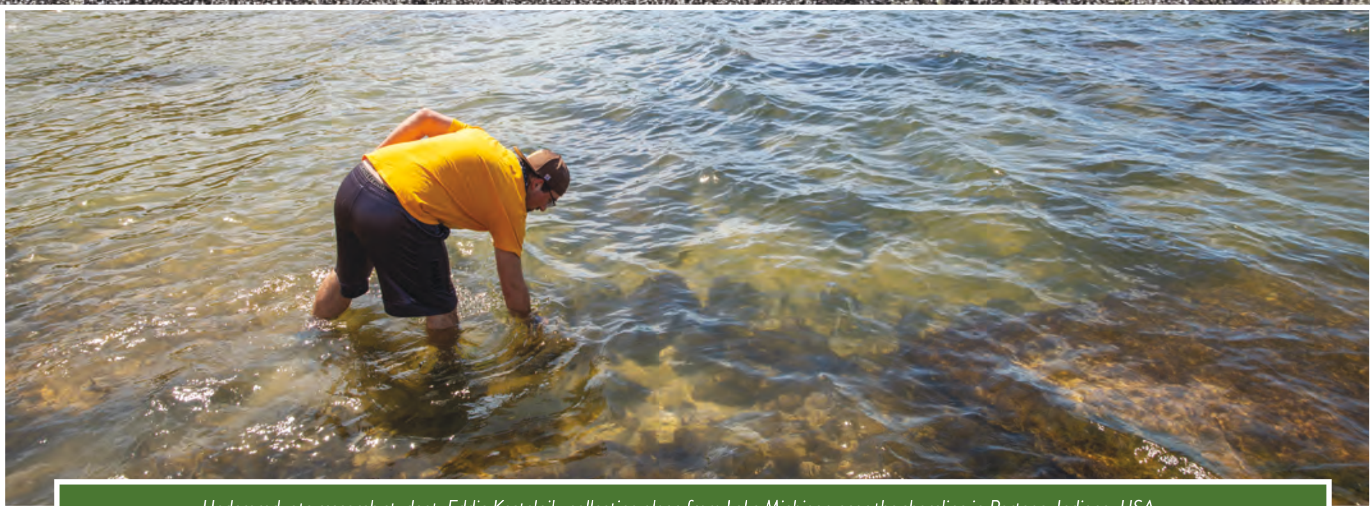
ACTIVITY 2 – PLASTIC-FREE DAY

Can you challenge yourself to be 100% plastic-free for one day? You can't buy anything wrapped in plastic – that means no packets of crisps, no chocolate bars and no bottles of fizzy drinks!

- What items would you normally use?
- How difficult was it to avoid these items? (Or how difficult do you think it's going to be?)
- Is there plastic-free shopping you will continue doing?
- Discuss how you and your family/school/community can reduce single-use plastic.

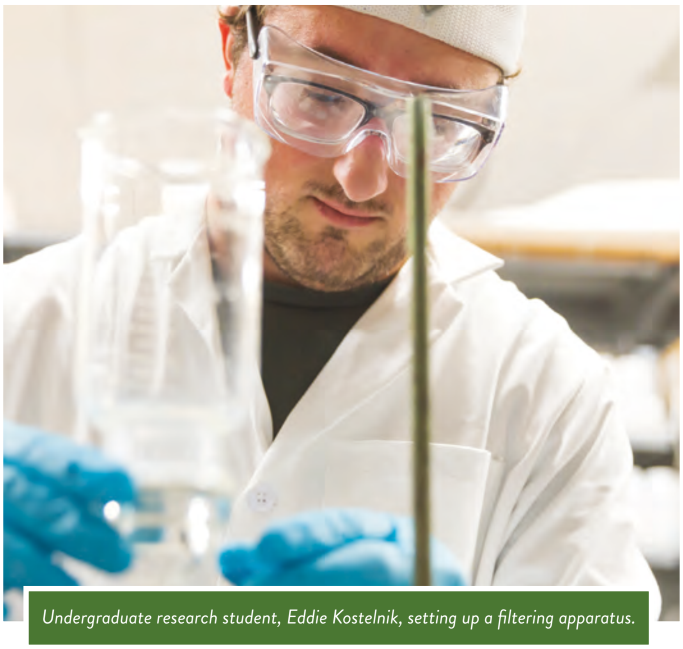


Julie Peller instructing undergraduate research students in procedures in the laminar flow hood. (Students: Ashley Smith and Emma Montgomery)

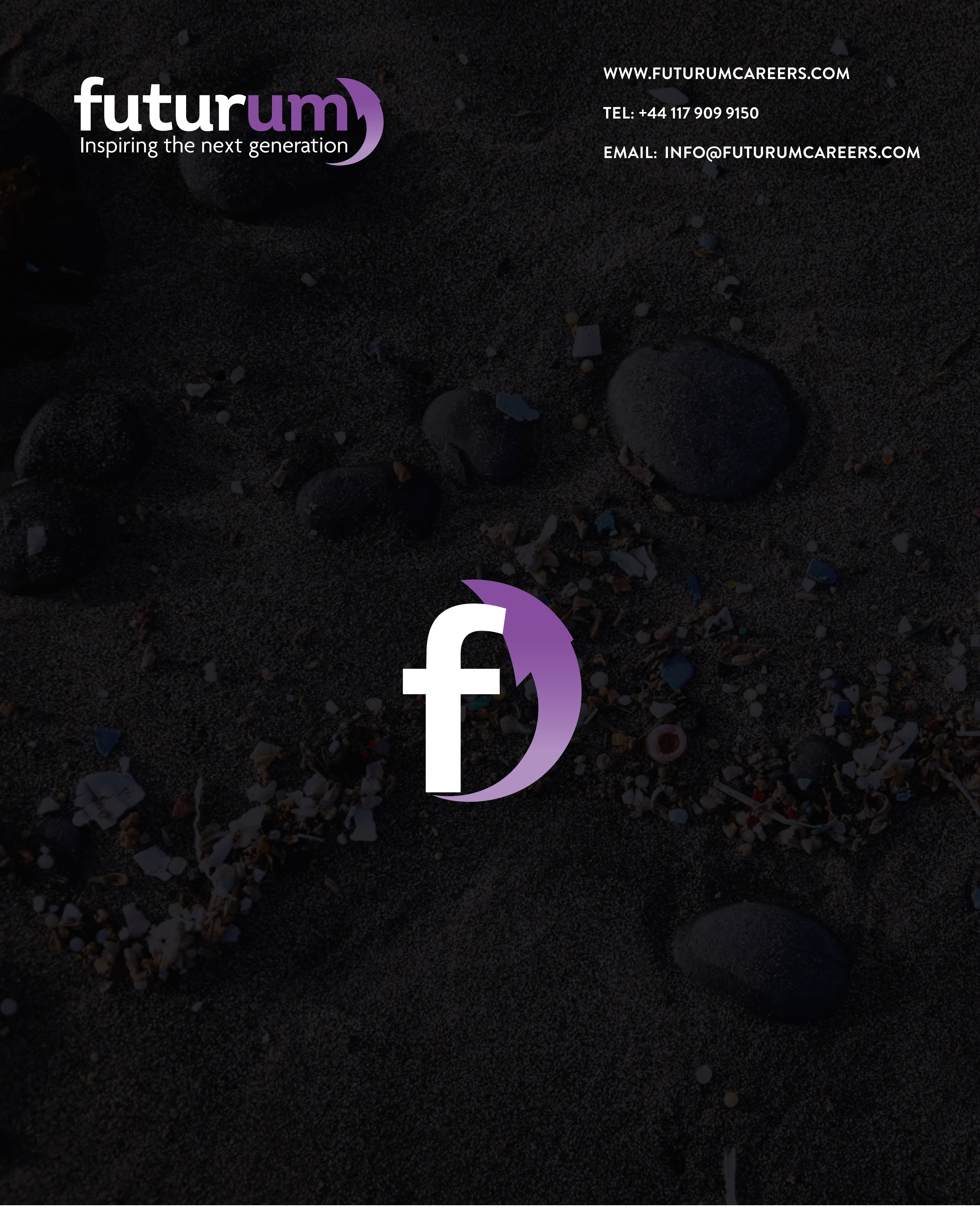


Undergraduate research student, Eddie Kostelnik, collecting algae from Lake Michigan near the shoreline in Portage, Indiana, USA.

Julie Peller working with undergraduate research student, Ashley Smith, using clean lab conditions, which include the laminar flow hood.



Undergraduate research student, Eddie Kostelnik, setting up a filtering apparatus.



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