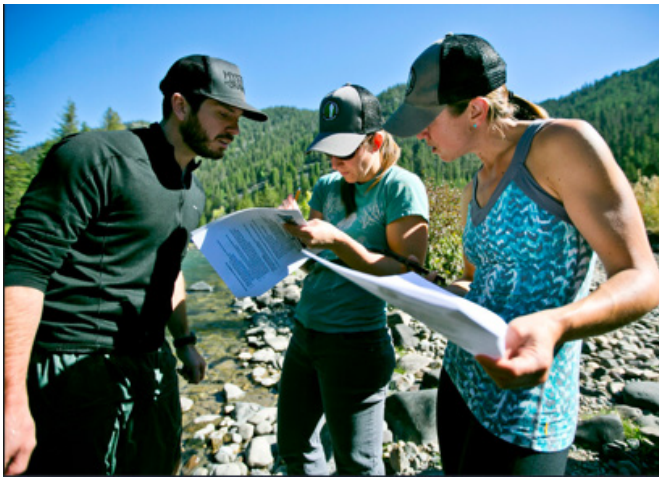
NATIONAL GEOGRAPHIC

CASE STUDY:
MAPPING MICROPLASTIC POLLUTION IN SEARCH OF SOLUTIONS

Katie Christiansen lives and works in Montana, United States, near Yellowstone National Park, the nation's first national park and the heart of the Gallatin watershed. Streams flowing from the rugged snow-capped Rocky Mountains of Yellowstone may look pristine. But the water is not pure. Christiansen led a research project that shows the watershed has a plastic problem.



Christiansen (right) and team. *Photo courtesy of Adventure Scientist*

Microplastics present a serious threat to the world's ecosystems because the chemicals in plastic have detrimental effects on human and animal health. Those impacts are cumulative in nature; that is, the effects of microplastic pollution will continue to grow over time as water and organisms become increasingly polluted.

A tangle of plastic in the belly of a dead bird makes it easy to see the impact of our plastic waste. Christiansen hopes people will also consider how the chemicals in the smallest particles of that plastic affect the bird and its habitat within a larger ecosystem. This is a challenge when microplastic pollution is nearly invisible; by definition microplastic is a particle smaller than a grain of rice, or under five millimeters in size. This is why Christiansen believes global and local communities must pay attention now, before the problem gets out of control. Just as DDT was an invisible toxin until bald eagles started dying, Christiansen wants to help people "see" microplastic pollution in order to understand both the problem and its solutions. Healthy ecosystems are essential, Christiansen says, "and without them, humans don't stand a chance."

Christiansen works with the conservation group Adventure Scientists, which launched the Global Microplastics Initiative in 2013. Adventure Scientists is a non-profit organization that coordinates environmental action by bringing together citizens and scientists. They partner with scientists who have specific data collection needs and then mobilize citizen volunteers who can collect that data as they travel to remote regions of the world.

Adventure Scientists believes their Global Microplastics Initiative dataset is one of the world's most extensive documentation of microplastic pollution to date. Their findings established that microplastics pollution is global in scale and in need of scientific and civic attention:[1]

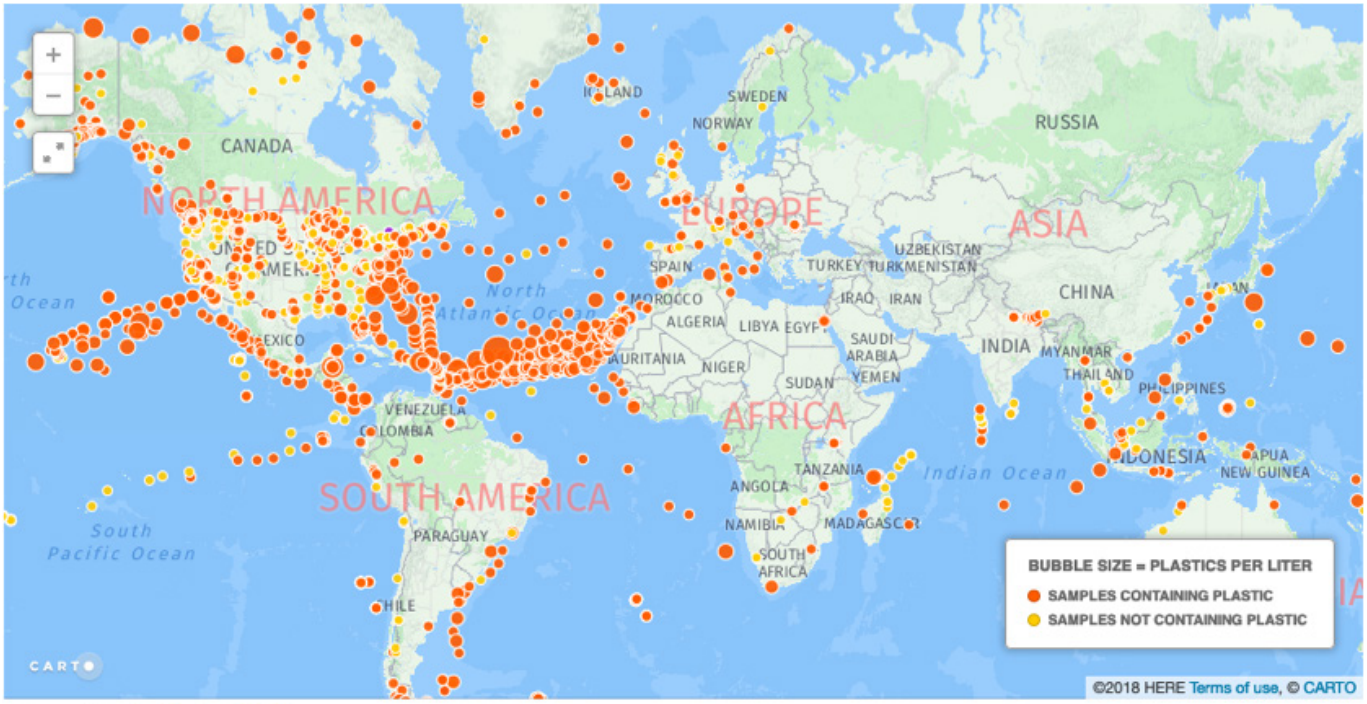
- 89 percent of samples collected around the world contained microplastic pollution.

[1] Katie Shepherd Christiansen, Global and Gallatin Microplastics Initiatives (Bozeman, MT: Adventure Scientists, 2018). https://www.adventurescientists.org/uploads/7/3/9/8/7398741/2018_microplastics-report_final.pdf

- On average, global water samples contained 11.8 pieces of microplastic per liter.
- Open ocean samples contained on average higher concentrations of the pollutant than did coastal samples, with polar regions containing the highest averages.
- Across studies, microfibers, as opposed to other types of microplastics, were dominant: microfibers composed 91 percent of marine particles and 92 percent of freshwater particles. Gallatin Microplastic Initiative: Study design and
  research questions

GALLATIN MICROPLASTIC INITIATIVE: STUDY DESIGN AND RESEARCH QUESTIONS

The Global Microplastic Initiative documented microplastic pollution accumulating rapidly around the world; this led Christiansen and the Adventure Scientists team to investigate the water in their backyard:



Map courtesy of Adventure Scientists.

Southwest Montana's Gallatin River. The Gallatin is one of three rivers that make up the headwaters of the Missouri-Mississippi watershed, the largest in the United States.

The Gallatin Microplastics Initiative was developed to extend the Worldwide Microplastics Project after all samples in a pilot survey along the Gallatin River were found to contain microplastic particles, some at unexpectedly high levels.

Christiansen worked closely with Abigail Barrows, a Marine Research Scientist and the study's Principal Investigator, to design a study to understand the amount and type of microplastics present in the Gallatin River and its tributaries.

For two consecutive years, seventy-two sample locations were seasonally sampled four times each year from 22 main Gallatin River sites and 50 tributary sites. In total, 774 of total samples were collected by 117 volunteers. Adventure Scientists believe the Gallatin Microplastics Initiative is the only watershed-scale study of microplastic pollution conducted with seasonal sample collection over multiple years.

The research questions driving the Gallatin Microplastics Initiative were:

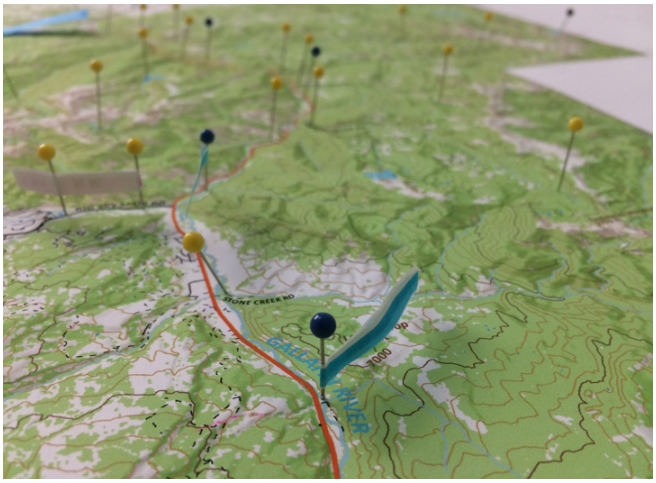
- What is the distribution of microplastic in the watershed?
- Where can it be found and in what concentrations?
- What shapes, sizes, colors, and plastic types of microplastic are present?

DATA COLLECTION PROTOCOLS AND TOOLS

Before launching the Gallatin study, Christiansen and Barrows carefully developed data collection protocols.

Developing a protocol for data collection and analysis is of the utmost importance because without standardization, the study's data and results will not be viewed as valid. Data that is collected randomly is viewed as lacking scientific rigor and it will fail to influence scientists and the public. For people to trust data, every data point needs to undergo the same process for collection.

A clear and consistent protocol was also essential for working with volunteer citizens, who had been recruited from the Gallatin community and were willing to go into the backcountry of Yellowstone to collect water samples at predetermined locations and at specific times during the year. Each volunteer was trained in the data collection protocol, tested on their knowledge of the collection process, and assigned two to four field collection sites.



Map of Gallatin watershed with pins identifying sampling locations
Photograph courtesy of Adventure Scientists.

Volunteers review the protocol for collecting water samples. Photo courtesy of Adventure Scientists.

The team also carefully considered all possible constraints, such as safety issues, equipment requirements, and other concerns that might be easy to take for granted before data collection began.

A geospatial project requires plotting collected data on a map. At Adventure Scientists, Christiansen and her team started with large maps and used pins and

Although they moved to digital tools and visualizations later, many volunteers found paper was still important, especially when digital tools ran out of batteries, apps experienced glitches, or online access wasn't available.

GALLATIN MICROPLASTIC INITIATIVE FINDINGS

Despite the unsettling results of the pilot, the Gallatin study samples demonstrated cleaner water than samples collected for the Global Microplastics Initiative. Whereas the majority of global water contained microplastic (89 percent of samples), slightly more than half of Gallatin samples (57 percent) contained microplastic pollution. Gallatin water was also found to contain less microplastic (an average of 1.2 pieces per liter) than global water samples, which contained 11.8 pieces of microplastic per liter. Furthermore, there was even less plastic found in the tributaries of the Gallatin River (0.97 pieces/L) in comparison to the main river (1.6 pieces/L).

Examination of the type of microplastic revealed that microfibers, as opposed to other types of microplastics, were dominant[2]. Microfibers composed 80 percent of Gallatin particles. In comparison, microfibers represented 91 percent of marine particles and 92 percent of fresh water particles in the global study samples.

Gallatin data was added to the database containing findings from the Global Microplastics Initiative. Taken together, the dataset provides valuable information for future research and action about where microplastic pollution is accumulating and in what quantities.

COLLECTED DATA IMPACTS MULTIPLE LEVELS

In the time since Christiansen and Adventure Scientists amassed the microplastic database, 331 groups and individuals have requested access to and are using the dataset. While data can be useful for informing policy changes, those changes tend to occur more slowly. Christiansen believes citizens are more likely to be highly motivated to improve the world we live in–and data can help us understand how to achieve those goals.

- **Government:** The U.S. EPA is using the dataset to study microplastics in sediment, tissue, and wastewater, and to work towards the designation of plastics as a pollutant.
- **Policy groups:** The Center for Biological Diversity has used the dataset to argue for water quality standards compliance in California and Washington.
- **Corporations** in the outdoor and apparel industries were motivated by these findings to understand and reduce the industry's microfiber pollution inputs. Beyond microfibers, business partners are innovating ways to reuse, reduce, or eliminate single-use plastics in their commerce.
- **Community members and project volunteers** have become advocates through their participation in the Global or Gallatin Microplastics Initiative. Many volunteers (80 percent) have taken steps to address microplastic or plastic pollution in their communities. Some examples include writing a letter to the editor, organizing or participating in community clean-ups, starting a recycling program, committing to using less plastic, and seeking employment or volunteer opportunities in

[2] Abigail P.W. Barrows, Katie S. Christiansen, Emma T. Bode, and Timothy J. Hoellein, "A Watershed-scale, Citizen Science Approach to Quantifying Microplastic Concentration in a Mixed Land-use River," Water Research, 147 (December 15, 2018): 382-392, https://doi.org/10.1016/j.watres.2018.10.013

conservation.

DATA CHANGES MINDS AND BEHAVIOR

Christiansen believes citizens who participate in Adventure Scientists' data collection efforts are encouraged to think more deeply about how they live in their communities and the world. Participating in data collection helps people take part in a larger effort to make positive changes in their world. The collected database of samples allows participants to begin asking bigger questions about how human use of plastic has contributed to environmental degradation and impacts on animal and human health.

This kind of storytelling can happen when data is shared with a community. Christiansen thinks some people are reluctant to make shifts in their beliefs and behavior without data because most changes are inconvenient for people. Telling a story around data helps people consider possible changes while also respecting everyone's desire to be informed. Ultimately, Christiansen says, "Data empowers."

HOW CAN TEACHERS AND STUDENTS CONTRIBUTE TO THIS WORK?

After their microplastic research, Christiansen's team understood that microplastic pollution is pervasive all over the world. Yet to fully understand the issue in individual watersheds or a particular city's drinking water requires more research. To achieve that kind of clarity requires individual communities that want to understand what's going on in their backyard, just as Adventure Scientists did in the Gallatin watershed. Only then can specific watersheds be compared to the global situation.

Although the microscopes and filtration needed to study microplastic pollution makes it somewhat more difficult than studying macroplastic pollution, Christiansen is confident it can be accomplished in a science classroom. Although the Adventure Scientists study used a vacuum filtration system to deal with high sediment loads and to process a significant amount of water, a complex filtration system is not essential in a school setting.

One important consideration for interested students, however, is preventing cross-contamination. This matters because it's common for microplastics to be present in the air. Teachers and students can set up protocols to ensure their findings are free from cross-contamination. Minimizing plastic in the lab setting and studying air "blanks" before examining data samples can help ensure successful classroom research.

LESSONS LEARNED FROM GALLATIN ABOUT COLLECTING GEOSPATIAL DATA

The Gallatin study is a particularly good model for projects that require geospatial data collection. Christiansen advises teachers and students to start by determining whether digital or analog collection tools will support your project best.

- One benefit of digital tools is that students are likely savvy with apps. The downside: there might be a learning curve to adopt a digital tool that could distract from your ultimate learning goals. There may be a larger investment of time upfront to ensure you pick a tool that fits the needs of the project.
- Explore apps that are free for educators. Check out citizen science organizations to learn what's available.
- Consider apps that can be widely distributed across your community or the world so that anyone can collect data with a standard form.
- Determine how you'll identify geospatial locations. Most smart phones can provide geospatial information through specific apps. You can also use larger landscape features (e.g. a road intersection or river confluence) to identify a location and its coordinates. Using GPS units is an option but requires more technical expertise.

In addition to data collection tools, also consider whether your project will use a physical or digital mapping approach—or both. Physical maps visualize data right away; they require only mapping skills, a large map, and pins or sticky notes. A digital approach requires online tools and access to GPS information, such as through online mapping programs or GIS technology.

You will also need to determine how to analyze your data. Spreadsheets are effective for capturing information and analysis, but they won't automatically map the data. Because data sets can end up being large and unwieldy, Christiansen advises planning up front how you will manage and organize data–especially as data comes in. She knows from experience that a messy data set is difficult to deal with and can threaten data quality.

PROMISING SOLUTIONS IN DEVELOPMENT

Christiansen has been tracking the influence of microplastic data and sees changes happening on several fronts.

One of the biggest contributors of microplastic fibers polluting our water is the laundering of clothes. Filtration systems are being developed for washing machines to capture fibers before they enter city systems.

The textile industry realizes they're big players in this issue. If synthetic fibers continue to be used and developed, the industry can and is considering ways to prevent microplastic pollution and mitigate dangerous toxicity concerns through the development of new types of materials and environmentally-friendly fabric processing.

Christiansen believes it is empowering for individuals to reduce their impact. Options that communities can be aware of include mindful purchasing habits, plastic reduction, and new products designed to

reduce microplastic pollution. She cautions consumers to think about how recycling plastics into new synthetic items can solve one issue (disposal) but still contribute to the microplastic problem if the new product will degrade into microplastic pieces or shed fibers.

How to use our synthetic clothes and still feel like we're making a difference? Christiansen recommends emphasizing making informed choices: "We all need to wash our clothes and we all need our rain jacket. Try to buy products that use environmentally friendly dyes and materials and make conscious choices to leave a smaller footprint."

TAKING ACTION

Like climate change, the issue of microplastic pollution will require action at multiple levels: local, national, global, and through corporations and industries. But unlike climate change, Christiansen points out that the issue has notbeen significantly impacted by political divisions that prevent us from taking action at all levels. Microplastics present an opportunity for global and local communities to come together for the environment and for human health.

ADDITIONAL RESOURCES

Adventure Scientists: https://www.adventurescientists.org/
Explore the work being done through the Adventure Scientists organization as they coordinate volunteer missions to collect data from remote locations for scientists and conservation partners.

The Adventure Scientists Microplastics Toolkit: https://www.adventurescientists.org/microplastics-toolkit-request.html
This kit is intended to enable replication of Adventure Scientists efforts in watersheds throughout the world.

Helping you do great science: CitSci.org: www.citsci.org
Access citizen science tools and resources that can support your own projects.

People-powered science: SciStarter.org: https://www.scistarter.org/
SciStarter provides a platform for people to find, join, and contribute to science through formal and informal research projects and events. Be sure to explore their overview for educators.