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## Here, There, and Everywhere: The Problem with Microplastics in Water and What Women Scientists Are Doing to Solve It

Pamela Lazos

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## Here, There, and Everywhere: The Problem with Microplastics in Water and What Women Scientists Are Doing to Solve It

### Abstract

Plastics – ubiquitous material we cannot seem to live without – are everywhere, but sadly we cannot live with plastics either, at least not peaceably, especially when you consider there will be more plastics in the ocean than fish by 2050. In the intervening years, the photodegradation of plastic resulting in microplastics pollution will be an even bigger problem, affecting every living creature in the ocean, and by extrapolation, mankind. The choices we make and the steps we take to combat the overabundance of plastics in our environment will dictate not just the next 30 years, but the fate of the world thereafter. This is not science fiction, but modern life. This article discusses the microplastics problem and some potential solutions.

### Keywords

microplastics, women in STEM, water pollution, plastic pollution

### Cover Page Footnote

\*Disclaimer: Pam Lazos is an environmental attorney serving as Senior Assistant Regional Counsel at the USEPA Region 3 office in Philadelphia where she works enforcing matters under the Clean Water Act and Safe Drinking Water Act. She is also an author, on the Board as VP of Communications for the Global Water Alliance, creator of the literary eco-blog [www.greenlifebluewater.earth](http://www.greenlifebluewater.earth) and serves on the editorial board of the wH2O Journal. Ms. Lazos' opinions are hers alone and do not represent those of the Agency.

# Here, There, and Everywhere: The Problem with Microplastics in Water and What Women Scientists Are Doing to Solve It

Pam Lazos

*Environmental Attorney\* and Writer*

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## KEY WORDS

microplastics, women in STEM, water pollution, plastic pollution

## CORRESPONDING AUTHOR

Pam Lazos: [pamlazos@gmail.com](mailto:pamlazos@gmail.com)

## ABSTRACT

Plastics — ubiquitous material we cannot seem to live without — are everywhere, but sadly we cannot live with plastics either, at least not peaceably, especially when you consider there will be more plastics in the ocean than fish by 2050. In the intervening years, the photodegradation of plastic resulting in microplastics pollution will be an even bigger problem, affecting every living creature in the ocean, and by extrapolation, mankind. The choices we make and the steps we take to combat the overabundance of plastics in our environment will dictate not just the next 30 years, but the fate of the world thereafter. This is not science fiction, but modern life. This article discusses the microplastics problem and some potential solutions.

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## 1 INTRODUCTION

Had Dr. Victor Frankenstein known his most advanced and innovative work would be the undoing of all he held dear, would he have ultimately created the creature known as Frankenstein? By inventing plastic, humankind has unlocked myriad possibilities in manufacturing and use, allowing us to touch the stars through space travel, and carry the universe via the internet in our pockets, courtesy of our smart phones, but at what cost to ourselves and the planet?

Think back to the pre-plastic era: milk arrived in heavy glass bottles delivered by the milkman; drippy waxed-paper-wrapped sandwiches rested in metal lunch boxes, and cars made of steel heavier than a couple Clydesdale horses

ruled the road. Now milk comes in lightweight plastic jugs; sandwiches lie in drip-proof single-use plastic bags nestled in feather-light plastic lunch containers; and cars are comprised of 60% steel composite (Fountain, 2009) both lighter and more durable than the old stuff because the weight has been offset by plastic. We would never have made it to the moon without plastic (Sparrow, 2019) and your snappy little iPhone might not even exist, at least not in its current incarnation (Plastics Business, 2013).

Yes, by creating plastic we have unlocked genius, but who ever thought genius would be so messy? (British Plastics Federation, © 2021). One lesson we have repeatedly failed to learn as a species, or perhaps simply ignored, is this: how do we get a handle on our waste stream before a product goes mainstream?

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## 2 A PLASTICS PRIMER

Plastic was first developed in 1868 by John Wesley Hyatt, an American Printer who responded to an offer of \$10,000 to the person who found an adequate substitute for ivory in billiard balls (National Inventors Hall of Fame, © 2021). Hyatt's contribution to society earned him a U.S. patent and a spot in the National Inventors Hall of Fame, but it was not until the 1940's that plastic entered its first golden age with the use of polyethylene in radar and the production of Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), Polytetrafluoroethylene (PTFE), and Low Density Polyethylene (LDPE), among others, for products such as albums, Teflon, Tupperware and Lycra (British Plastics Federation, © 2021) that the manufacturing of plastics skyrocketed.

By the 1950's, the U.S. was in the midst of a consumer revolution with calls for everything from plastic furniture to foodware, clothing and accessories like bakelite (ACS, 1993), Barbie dolls, Legos, and even the hula hoop.

Figure 1: The BPF Plastics Timeline, © 2021



Since then, plastic production has grown exponentially from approximately 2 million tons in 1950 to 381 million tons in 2015 (Ritchie H, and Roser M, 2018) with no sign of slowing down.

To make plastic, manufacturers apply heat to petroleum to produce a polymer not found in nature. By heating or cracking hydrocarbons in products such as oil, natural gas, or coal, we have created a versatile and enduring suite of plastic products using a wide range of temperatures (*American Chemistry Council*, © 2005-2021). The strength of these polymers is outstanding for something seemingly so delicate — as anyone who's ever tried to take the little plastic wrap off the medicine bottle without the help of scissors has figured out — and extremely durable, taking hundreds or perhaps thousands of years to break down, depending on where the waste goes. Plastic in landfills might not ever breakdown since most bacteria are not capable of degrading the polymer,

whereas plastic in the oceans keeps degrading into smaller and smaller pieces due to photodegradation.

Either way, we will never know for sure since none of us will be alive long enough to take note (Harris W, 2010). Regardless of whether it's a hundred or a thousand years, 90% of all plastics ever created is still on earth in some form. To date, 8.3 billion metric tons of plastic have been made (Parker L, 2018). At that rate of production and without addressing the concurrent waste stream, no one reading this should be surprised to learn that we'll be drowning in plastic within a few decades.

Perhaps you've heard some of the often-repeated facts about plastic. If not, here are a few:

- In the 70 years since plastic entered the consumer mainstream, we have created almost 9 billion tons of it, 92% of which is not recycled and still on the planet in some form (Ferris R, 2017);
- a straw used for 15 minutes during lunch will live for hundreds of years in the ocean, and 500 million of them are used *everyday* in America, enough to circle the world twice (EcoWatch, 2014);
- two million single-use plastic bags with an average working life of 15 minutes are distributed worldwide every minute (EcoWatch, 2014);
- one million plastic bottles are purchased every minute; at our current rate of production, by 2050, there will be more plastic in the ocean than fish, much of it as microplastics (EcoWatch, 2014).

### What are microplastics?

Microplastics are defined as a polymer particle less than 5mm in size (0.19685 inches) (NOAA, undated), and are considered an emerging contaminant of concern, meaning we are just beginning to study and understand the health effects (USEPA, 2020).

Thanks to our absolute obsession with plastic, microplastics are now everywhere, too: in our oceans, rainwater, drinking water, air, even our food supply, and fish (Stierwalt S, 2020). According to the U.S. Geological Survey, about 12% of fish in the United States contain microplastics (USGS, undated), bits so tiny you wouldn't even notice consuming them (Stierwalt S, 2020), while a 2020 study from University of California San Diego found one in four fish from a San Diego stream to contain microplastics (Science Daily, 2020).

### The fate and transport of microplastics.

The term "fate and transport" describes the process by which chemicals enter, travel and degrade in the environment over time. Microplastics enter the water in various ways such as through trash, including used water bottles and single-use bags that break down over time through photodegradation, air deposition, and as effluent leaving the wastewater treatment plants, to name a few. The National Institute of Health estimated that in 2010, of the 275 million metric tons of plastic waste generated, anywhere from 4.8 to 12.7 million metric

tons ended up in the ocean (Jambeck J, 2015) where it would continue to degrade into smaller and smaller particles, becoming microplastics over time. “In 2014, a global analysis measured ocean plastic at a quarter of a billion metric tons, much of it suspended in small rice-sized particles,” (Parker, L. 2016). Add COVID-19 to the mix where people are shopping online now more than ever — and irresponsibly littering the ground with discarded face masks that eventually make their way to the water — and the amount of ocean plastic goes up astronomically. Oceana International estimated over 22 million pounds of packaging from Amazon purchases alone entered the waterways in 2019 (Oceana International, 2020).

It’s easy to get lost in these numbers, especially when microfibers from clothing such as fleece jackets, nylon pants, and water-wicking shirts are sloughing off microscopic bits of fiber in the thousands with each washing. In fact, trillions of tiny strands of synthetic fibers are shed every year from towels, carpets, clothing, polyester, nylon, and spandex, continuing to degrade over time into smaller and smaller pieces. In some instances, the product started out tiny as is the case with microbeads which manufacturers had been adding to health and beauty products as an exfoliant in face scrubs and in toothpaste for the last 50 years (NOAA, undated). President Obama banned the addition of microbeads with the signing the Microbead-Free Waters Act of 2015 (H.R. 1321, 2015).

Once these tiny fibers leave your washing machine and enter the wastewater collection system, they will be transported for processing at the wastewater treatment plant where anywhere from 1-12% of them will slip by the treatment facilities digesters, clarifiers, and other equipment (Conley K, et al., 2019) and out into the river where the fibers enter the aquatic food chain.

Already, scientists are finding microplastics in the human placenta (Ragusa, A., 2021), raising both questions and alarms about a race of “cyborg babies,” (BusinessToday.In, 2020). Since the placenta provides the interface between mother and baby, the fact that microplastics have been discovered in the womb leads to a multitude of inquiries about what the presence of microplastic will do to fetal and newborn health.

So why are scientists only now sounding the alarm regarding microplastics? Perhaps it was that German study that found microfibers in all 24 brands of beer being studied, including their most popular, Beck’s, that got the scientists’ attention (Letzter R, 2014).

### **The Health Effects of Microplastics: high risk or much ado about nothing?**

Whatever the reason, the full-blown study of microplastics has been slow in coming. Part of it has to do with the varying sizes and sheer number of types of plastics. While microplastic particles are considered to be 5 mm or less, there are many instances where a microscope is required even to spot the presence of microplastics. Add that to the ubiquitous nature of this polymer and it is difficult to keep track of all the entryways — both point and non-point sources — into the en-

vironment.

Take a plastic straw, for example. While aquatic life might be drawn to the brightly colored plastic floating around in the ocean and consider it an appetizer, the seabird, fish, or turtle at least has the option to accept or reject the morsel. Microplastics offer no such opportunity for decision; they are simply present in the water column, in the sediment, and in the sand, present, yet neither seen nor recognizable.

Both plastics and most hydrocarbon-based pollutants are hydrophobic. When the two meet, the pollutants adhere to the microplastics, making it easier for the pollutants, including pathogenic microorganisms, to travel, bound on the backs of the microplastics as they float past all the equipment in the wastewater treatment plant meant to stop them. Wastewater treatment plants — the *unsung heroes* of the modern age according to Dr. Chelsea Rochman, professor at the University of Toronto — aren’t yet geared to reduce microplastics to zero (Rochman, C, 2018). That kind of upgrade is extremely expensive— plus the wastewater treatment plant is preoccupied with removing pathogens such as *E. coli* and other contaminants found in our waste stream that *we know* can kill us. As an undiagnosed problem that may or may not cause harm to human health and the environment, microplastics are at the bottom of the hierarchy threat even as they ride the wastewater treatment plant’s effluent back to the river where fish, turtles, frogs and other wildlife will ultimately ingest them, most often unwittingly.

There are so many unanswered questions. What will microplastics do to our chemical composition as humans? Do they change the nutritional value of our food or impede its absorption? Do the chemicals that go into making plastics — a petroleum-based product — bioaccumulate in our bodies? What about the microplastics themselves? Can our bodies eliminate them, or do they take up residence in our organs or fatty tissue? Are they inert or can they metastasize? If plastic doesn’t break down while outside of our bodies then reason suggests the same thing is happening inside our bodies, but is that truly the case?

### **You can’t manage what you can’t measure.**

There is as yet no universally accepted mode of measuring microplastics and much of that has to do with the lack of standardized methods for making plastic — size, type, polymers and powders vary by use and design — polyethylene, polypropene, polystyrene, pyroclastic (created by fire), the list goes on — and they all have different heating levels which means that there is no *one size fits all* sampling, or recycling protocol, making it difficult to quantify, study, and regulate (Besley, A, 2016).

In fact, researchers didn’t even begin to study microplastics until 2011 with a scattershot approach that was less than satisfying. In 2018, a few commercial manufacturers like Patagonia and REI teamed up with Ocean Wise (Ocean Wise, 2018) to conduct their own studies on microplastics (Chastain, S, undated) since estimates indicated that a third

of the ocean's microplastics were from synthetic fibers (Armstrong M., 2019). In February of 2020, five dozen researchers across various spectrums including major universities, government, environmental groups, tribes, and water sanitation folks, gathered to discuss the issue (Flaccus G., 2020).

### What's STEM Got to Do with It?

Time for a short PSA — public service announcement — on women in science, technology, engineering, and math, or STEM. We'll get back to microplastics in a minute, I promise.

It hasn't always been easy for generations of women whose life goals included something more than the traditional wife and mother tract. Today, women entering the workforce may have no idea how hard their female colleagues had it in the 70's. Before Ruth Bader Ginsberg made it look easy, arguing before the Supreme Court and winning some landmark decisions under the Equal Protection Clause of the 14th Amendment for the betterment of all people, but especially women (Huff B, 2015), a girl couldn't open a bank account or get a credit card (Singh D, 2020) without her husband's approval (Singh D, 2020).

Such tidbits of historical information might shock today's working ladies, but I came of age in the 80's and while things were loosening up, they are much better today. To take a step back in time, I recently watched *Working Girl*, starring Melody Griffith and Harrison Ford (IMDb, 1988) with my own girls, aged 25 and 20, and while they understood the inherent parody of the movie, both were savvy enough to realize that as recently as the late 80's, a woman needed to take extraordinary steps to realize her career goals.

Thirty years later, much has changed. Women are significant contributors to the economy, yet that doesn't mean we've leveled the playing field. In 2019, women made up only 27% of the workforce in STEM-related careers yet they comprised approximately 47% of the workforce overall (Catalyst, 2020).

**Figure 2: Research Scientists conducting an assessment of a 100-meter stream reach located in the Catskills within the Delaware River watershed**



Photo courtesy: Meg O'Donnell

While women in the workforce may be increasing overall, women in STEM careers have not yet fully arrived. In the last decade, organizations such as Girls Scouts of America (Girl Scouts, 2016-2020), and the Association of Junior Leagues International through its local chapters (JLL, 2021) have realized that young girls need some serious mentoring support if we're going to steer more of them toward careers in STEM.

End of PSA.

Speaking of STEM...

## 3 SPOTLIGHT ON KELLY SOMERS:

If you ask Kelly Somers what her perfect day at the office looks like, she would tell you it's a day on the river taking water samples. As a Physical Scientist in the U.S. Environmental Protection Agency's Water Division, where she's been working for the last seven years, Somers job description requires her to log some serious boat time, taking samples and cataloging the results.

Somers holds an M.S. in Environmental Science from Drexel University and considers herself a science geek, participating as a Science Olympiad as far back as middle school. The first scientist in her family, when she finished grad school, Somers worked at the University of Delaware (UD) for a year as a researcher studying wetlands loss using remote sensing. Following her stint at UD, Somers worked in the private sector for a few years before joining the US Environmental Protection Agency (EPA). A Jersey girl and self-professed adrenaline junkie who is always looking for "fun new ways to see the planet from a different perspective," Kelly spent summers at the beach, working at an arcade on the boardwalk where she added *skee-ball whiz* to her nascent work history. It was probably her very first job as an onsite youth sports coordinator, and referee for basketball and soccer at the local YMCA that seeded Somers easy-going leadership style and laid the foundation for the organizational skills so crucial to research. About her decision to go into a STEM career, Somers says that "science and math always just made sense to me" because it provided clean, provable answers.

"I like a complex problem leading to a solution rather than a problem leading to many complex solutions." Somers recalls that after spending a semester in Costa Rica studying rain-forest ecology while in college, her path as an environmental scientist became clear.

"Studying ecology and the plant and animal relationships that build an ecosystem fascinated me. As my career and interests developed, I began to focus most of my work in watersheds and how to keep watersheds clean and healthy." For Somers, born in 1985, it's always been about science. She credits her current position as EPA's *Trash Free Waters* coordinator, "looking for innovative ways to stem the flow of trash from entering waterways," with sparking her interest in microplastics.

“My favorite opportunity was when I got to spend a few weeks in Narragansett, Rhode Island at EPA’s ORD [Office of Research and Development] microplastics lab learning first hand the complex process of isolating, extracting, and characterizing microplastics from various sampling media. I hadn’t worked in a laboratory environment in many years and it was exciting to re-engage with that practice of science.”

Today, Somers’ main focus is sediment collection and sampling in the urbanized areas within EPA Region 3 [comprising Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and Washington, D.C.] where many rivers are vulnerable to the plastic and microplastic pollution threatening the watersheds and estuaries and impacting surrounding ecosystems. In addition to its regulatory efforts to control pollution, EPA also manages watershed partnership programs such as *Urban Waters* (USEPA, 2021), and the *National Estuary Program*.

According to Somers, sampling will be a key component in solving the microplastics puzzle.

“Microplastics are an emerging contaminant; therefore, scientists are still working on creating high quality methods for sampling, detecting and identifying microplastics. Microplastics are also found in various media like within the air, in the sand, or in the water so each media needs its own protocol. Once the sample is collected, then it needs to be processed in the lab. The microplastics need to be extracted and isolated from the media so it can be analyzed. The tools and devices that are used to analyze the microplastics are very intricate, specialized and expensive. It’s a complicated process. As researchers continue to study this emerging contaminant, methods will be refined and processes hopefully streamlined to make microplastic sampling more readily available.”

**Figure 3: Kelly Somers on a boat run to gather river sediment for microplastics sampling**



While we’re waiting for the analysis piece to catch up, what can the average consumer do? Somers says:

“I think about this often. How can I be a smart consumer? What choices can I make to avoid my plastic use? One thing I personally do is check my clothing labels. Microfibers are considered to be the most prevalent type of microplastic in the ocean. Microfibers are thought to enter the environment through your washing machine effluent. Synthetic fabrics such as polyester shed when being washed and those fibers are drained out and eventually enter the waterways. I try my best to purchase non-synthetic clothing and linens for my home such as cotton and wool to help reduce plastic entering our environment. Another interesting fact is that the *Ocean Conservancy* found the top 10 plastic items on beach cleanups are ‘single-use plastics’. Examples of single-use plastics are disposable silverware, plastic lids, plastic bags, etc. As a consumer, I politely ask the servers to not provide me with a straw and if I get take-away food, I bring my own bag and use my silverware at home. Little changes in your life can add up to big impacts! Be a smart consumer. Choose reusable and avoid single use plastics.”



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—Kelly Somers

Spoken as a woman who loves her job and loves her work. It’s no surprise then that Somers is rarely *off-duty*; it’s just who she is. Somers had this to add about how we consumers can help:

“There are some emerging technologies that are being used to stop macroplastics from entering waterways. Trash Traps, hydrodynamic separators, street sweeping ... a floating trash can. These *Sea Bins* have been found to remove macro and microplastics from the water. Another cool technology that I read about is the Cora Ball which can help trap microplastics

in your clothes washer before the water is drained out. Recycling is very important but again, I think we need to shift our behaviors and start looking towards reusable water bottles. I was watching a show on Netflix last week, and I was elated to see the amount of water bottle re-filling states that are in place in Paris. They even have seltzer water stations. [(Angelova M, 20200] This clean water source allowed residents and tourists to refill their reusable water bottles, saved money for the consumer and reduced the plastic waste in Paris. Could you imagine if every major city did this?!” [San Francisco already does this: (San Francisco Water Power Sewer, 2011-2018)] I can’t stress it enough, but it comes down to the individual person to change their behaviors. Bring a water bottle with you and fill up. Bring a reusable mug with you to get your morning cup of Wawa Coffee! Bring reusable bags out shopping — not just to the grocery store. Skip the straw. Check your clothing tags and try to avoid synthetic fibers. Dispose of your garbage appropriately [i.e., compost]. It really starts with each person to make small changes in their life to make a big impact.”

So true, Ms. Somers. In an age where we have a million choices making it difficult to decide which cereal to buy, there’s one thing that we should all agree on: the future health of our planet begins with each and every one of us.

#### **4 SPOTLIGHT ON MEG O’DONNELL:**

Ask Meg O’Donnell about microplastics, and her eyes become animated. O’Donnell works at the *Delaware County Regional Water Authority* where she oversees lab testing and analysis, reviews spill plans and permits, and prepares permits and inspection reports for the pretreatment of its industrial water program. Before that, O’Donnell spent six years at the *Academy of Natural Sciences* in Philadelphia as a staff scientist and then lab manager, overseeing a dozen seasonal technicians in conducting over 200 stream sampling events in four states with the goal of assessing habitat, soil, stormwater, interdisciplinary field research of algae, fish, surface water, salamanders and aquatic macroinvertebrates. In addition, she oversaw installation and maintenance of the analytical field equipment at 35 different sites; designed and implemented an agricultural study examining the impact of pollution on aquatic macroinvertebrates; and wrote field sampling protocols; among a host of other things. Given O’Donnell’s enthusiasm for sampling, it’s no surprise she has a special interest in getting microplastics out of wastewater.

The current microplastics problem, as O’Donnell sees it, is a matter of degrees. Today’s drinking water treatment plants are very good at removing contaminants from our water, but they only get us so far. It’s not that the technology isn’t there, but that it’s prohibitively expensive to do on a large scale. Currently, most water treatment facilities are incapable of filtering out particles <10µm, (that is 10 micrometer which means they are particles less than 10<sup>-6</sup> or 0.000001 of

a meter, or 0.001 of a millimeter). Microplastics are defined as particles of 500-0.1µm and nano plastics are defined as particles <0.1µm. At that level where you need a microscope [such as a Scanning Electron Microscope] to see these particles, there is no way the water filtration systems currently in use are catching everything.

While there are pressure-driven membrane separation technologies available such as microfiltration, nanofiltration, ultrafiltration, and reverse osmosis that can remove the tiniest of particulates (Nicholas N. 2019), the cost is prohibitive for the waste water treatment plant and doesn’t include maintenance and filter change-outs which are not only costly, but require a certain level of attention and upkeep.

“Most consumers buy more affordable filtration options such as carbon filters that are not capable of removing microplastics and are individually engineered to target a specific type or group of contaminants,” says O’Donnell. Upgrading public water systems to the level required to assure complete removal can be extremely costly, depending on a variety of factors, including the age and size of the plant.

O’Donnell adds: “There are activated charcoal filters that reduce microplastics but not down to 0.1 micron. They provide a finer filtration than municipalities but still leave a significant concentration in the water. Charcoal water filter companies claiming microplastics removal may use tactful jargon that may not be well understood by consumers. A carbon filter may say that it completely eliminates microplastics. However, in the small print, it indicates that it is to a particle size of 3 microns and larger. As a result, microplastics in the range of <3.0 - 0.1 micron will still remain in the filtered water.”

Given the limited research on what microplastics can do to the human body, it is uncertain as to when the regulated community will consider this a problem worthy of the significant cash infusion needed to complete the upgrades, although O’Donnell doesn’t think that will happen anytime soon.

“Our drinking water treatment plants are constantly faced with new unregulated contaminants of emerging concern and they are not equipped to filter them out. Until there is evidence that microplastics are a proven public health concern coupled with an enforceable MCL (Maximum Contaminant Level) issued by the EPA, I would expect drinking water treatment plants to move slowly on costly changes required for ultra-fine filtration.”

Nor is there any push in the plastic trade to self-regulate, which, given the myriad and divergent types of plastics being manufactured today seems to beg for industry input, especially as it relates to the waste stream. This fact leads to O’Donnell’s greatest concern — industry’s failure not just to recycle, but to even account for the waste stream, a huge transgression against nature knowing how stubbornly plastics persist in the environment, and resultantly, in humans.

“Studies show that we manufacture one million plastic bottles every minute internationally with an increase of 20%



expected by 2021. Our excessive production has resulted in the Pacific trash vortex, large masses of floating plastics in the ocean that are now the size of Texas. Floating debris accounts for just 1% of plastics in the ocean. The ubiquitous nature of this problem was confirmed when in March of 2020 a new species of crustacea located in the ocean's deepest trenches was named after plastic was discovered in the gut content analysis. There is a significant paucity of information on human impact. Available studies indicate that our bodies excrete microplastics allowing them to pass through with no detectable impact. However, I am sure that we will eventually start to see new studies on health effects as time goes on, especially in vulnerable populations. It is an overwhelming issue that needs to be mitigated on a larger scale to reduce plastic production in addition to behavioral changes from the consumer. I am hoping that single-use plastic bags are eventually phased out as more states adopt bans."



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— Meg O'Donnell

O'Donnell adds that there is a "misconception" around bottled water, stating that bottled water manufacturers are "not eliminating microplastics like the general public believes or a lot of other contaminants as [bottled water manufacturers] are not subject to the same regulations as the public utilities."

As someone who has written and opined on the perils of single-use plastic and bottled water from many angles — the theft of a common resource; the inundation of the world with single-use plastic bottles in landfills; the lack of regulation of bottled water, rendering it inherently less safe than tap water — I wholeheartedly agree with O'Donnell's analysis.

I would be remiss if I did not point out what is not obvious. No matter the failure of drinking water treatment plants to capture the microns and the nanos, the smallest of the small contaminants, they are still doing a stellar job of catching the contaminants the EPA regulates and providing safe drinking water to the average consumer. Bottled water can make no such claim.

## So — where do we go from here?

Can regulations save us? Perhaps, but the EPA's Safe Drinking Water Act Contaminant Candidate Lists (CCL) does not list microplastics as a class/type of contaminant. According to the EPA:

"The drinking water CCL is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations but are known or anticipated to occur in public water systems. Contaminants listed on the CCL may require future regulation under the Safe Drinking Water Act (SDWA). SDWA requires EPA to publish the CCL every five years. SDWA directs the Agency to consider the health effects and occurrence information for unregulated contaminants as the Agency makes decisions to place contaminants on the list. SDWA further specifies that the Agency place those contaminants on the list that present the greatest public health concern related to exposure from drinking water. EPA uses the CCL to identify priority contaminants for regulatory decision making and information collection" (USEPA, 2021).

While some components of plastic are on the CCL, plastic as a category hasn't made the list which means the breakdown of plastics into microplastics into our air, water and soil will continue, for now, unregulated, unabated, and undeterred.

In *Three Lessons for the Microplastics Voyage*, David Sedlak, an American environmental engineer and Professor at the University of California, Berkeley, states that the only way to make progress in combating this emerging contaminant of concern is to document the adverse effects in the field, demonstrate the danger to human health, and get a handle on the exponential cost — meaning, don't choke on it because, in the end, it's cheaper than letting the problem go unchecked — and the vagaries of blame (ACS, 2017).

As discussed above, you can't manage what you can't measure. Without uniform data which has been the biggest roadblock to studying microplastics we can never hope to defeat our enemy. The National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program has developed field testing guidelines and laboratory protocols (NOAA Marine Debris Program, 2015) that will allow for uniform testing and more formal scientific methods of analysis, engaging scientists at the University of Washington Tacoma and George Mason University, among others (NOAA, 2016), and developing a toolkit for educators (NOAA, 2017). Still, the tests are not perfect and each medium brings its own challenges. By standardizing field testing methods for sand, sediment, and surface water for microplastics sample collection, scientists will be better equipped to study and understand the fate and transport of these ubiquitous polymers.

Second, while the photos of a whale with a belly full of plastic can be *gut-wrenching*, we can, and do, avert our eyes when it's no longer convenient to think about, leaving the adverse affects to the planet and ourselves *out of sight, out*

*of mind*. While cogitation about our many roads to perdition as a result of a collective failure to make water protection a priority keeps me up at night, most of the people I know have no clue as to how precarious our position is so their sleep goes unencumbered. Cause and effect is a very powerful tool, but when the cause happens 20 or 30 years before the effect, people forget to connect the dots. In a society used to instant gratification, if the bottom isn't actively falling out, no one is really paying attention, a view that lacks long-range vision. The fate of our marine and freshwater inhabitants will be our fate as well. It will just take us humans longer to get there. If you need proof of this, look here: despite scientists' years-long admonition that the ocean is running out of fish even nations who have pledged to do something about it are shirking their duties (Dean A., 2019). By the time the sushi bars are empty, it will be too late.

Third, we have got to stop worrying about the cost. I'm not saying cost does not matter, but when you calculate the loss of resources, the untempered health effects/costs, and inflation, to name a few, you are talking levels of magnitude that would never have been imaginable at the problem's inception. We've also got to stop blaming the few companies who make the products just to make ourselves feel better. Yes, they are responsible for creating the product — and as a result, should pay more towards the cleanup and remediation of the problem — but a few bazillion of us consumers purchased those same products even after we learned about the health effects. As consumers, we need to keep the pressure on the manufacturers to provide us with sustainable and environmentally friendly products if this consumer-driven experiment is going to work. Regulations will never be enough without consumer buy-in.

How do we inform the public? By making the data accessible to all in a way that is approachable and non-threatening so everyone can understand and appreciate the risk. Dr. Chelsea Rochman, who has been studying plastic pollution for over a decade, is the head of the Rochman Lab at the University of Toronto where they study freshwater and marine ecology, ecotoxicology, environmental chemistry, and conservation. Dr. Rochman who spends “a lot of time talking to policy makers,” has this to say:

“I did not get into science because I was just interested in science. I love advancing basic knowledge, of course, but I became a scientist because I recognize the value in using scientific information to inform decision-making ... so that ... decisions are made based on fact. We spend a lot of time working on the sources of plastic into the ocean, including microfibers, and also into the lakes, the contamination once it gets into our water bodies, and the impacts, and we spend a lot of time taking that information and trying to get it written in a way that it's accessible to everyone, and then putting it in the hands of the decision-makers so that hopefully, good decisions are made.”

There is no question that a fuller dialogue including all stakeholders about the scope of the problem will inevitably lead to more satisfying results so let's get that conversation going. In the interim, let's take another look at how science can help us along.

### What's Innovation Got to Do With It?

Now that the monster has escaped the laboratory, how do we coax it back in before we drown in our own plastic detritus? Certainly, 70 years is enough time to realize the extent of our error, correct course, and chart new navigation with science as our guide, but what shall we focus on first?

We need to capitalize on our scientific breakthroughs. Science got us here and science can get us out, but we need to start dreaming — novel ideas about reformulating plastics packaging and tax breaks to coax manufacturers away from petroleum-based products and fabrics toward fully compostable packaging and biodegradable bio-polyester fibers.

Researchers at the University of Portsmouth in the U.K. took a plastic-eating enzyme, PETase (PET: Polyethylene Terephthalate) first discovered in Japan in 2016 and merged it with a newly discovered enzyme, MHETase (MHET: Mono-(2-hydroxyethyl)terephthalic acid), which speeds up the breakdown of plastic sixfold (YaleEnvironment360, 2020). So we're definitely keeping PETase and MHETase in our sights to help us with the recycling component. There's also compostable straws and other food packaging made from plants (Royte E., 2019) that takes weeks instead of centuries to break down.

Then there's my personal favorite — *pestalotiopsis* — a mushroom that eats plastic (Standard E, 2011), leaving behind a residue that can be used to make furniture or building materials and is also edible (Denhof S, 2019).

What about recycling plastic pellets into roadways? We produce about 350 million metric tons of asphalt a year (Peters A. 2019). Why not use recycled plastic instead? Durable by nature, it could last up to 50 years which is three times more than typical asphalt (Rogers P, 2020).

Then there's the *Plastic Bank*, a worldwide chain of stores where everything from school tuition to cooking fuel is available for purchase in exchange for plastic garbage. Imagine that kind of recycling incentive worldwide (Plastic Bank, 2021)!

We could also use some advertising help. Remember all the ads for recycling sponsored by the petroleum companies? They knew plastics recycling could never keep up with plastics demand and eventually, we'd all be swimming in it, but that didn't stop them from putting the onus on the consumer (Sullivan S, 2020). The earth needs a good ad campaign, one to counteract all the misinformation out there, and probably a good lawyer, too.

## Is this the Beginning of the End or the End of the Beginning?

I saw a meme the other day that said, “if you’re paying \$3.00 for a bottle of Smart Water, it isn’t working.” I think this sums up our thinking about plastics, especially single-use plastics. We are a consumer-driven society, but only because advertisers have convinced us to be. Yet overconsumption of the earth’s resources — Americans comprise 5% of the world’s population, but use 24% of its resources — is simply not sustainable (International Business Guide, undated). We don’t have to be a nation of over-consumers; we can decide right now to use something until it’s no longer useful and then make sure that whatever happens to it next actually benefits someone else, or even society, rather than detracts from it. Every product we make should be thought of not only in the first instance — as in the sale of — but in its final incarnation as in reducing, reusing, and recycling the waste. That is the definition of a circular economy.

We’ll need cooperation on a grand scale that includes the political will, legislative help, governmental leadership, and consumer advocacy, and the stakeholders need to agree on how to move forward — i.e., learn to compromise, something scarce, at least in America today — or we’re going to spend significantly more time floundering. We need the government to provide tax incentives for innovators and a penalty scheme for polluters. We need funding for research and development from the corporations themselves. We need the Federal and state governments and academic institutions to draw in talent by funding grants, state revolving funds, and academic research grants, and we need to reward innovation with government and private contracts. All of this will go into the toolbox we’ll use to fight the monster until we force it back into the shadows or better, make it our friend.

### Say we manage the monster — what then?

We’ve all seen the pictures showing the plastic contents of bird and whale stomachs, the notorious video of the sea turtle with a straw stuck up its nose, the six-pack rings stuck around a bird’s neck, the cormorant covered in oil, but what we have not yet seen are the adverse health effects of microplastics because, until recently, they were too tiny to consider. While many exciting discoveries on the horizon will help us combat the plastic monster, our best defense is to reduce at the source since once a resource has been compromised, it is impossible to return it to a pristine state. Let’s begin now to think differently about our products — from cradle to grave — not just from the manufacturing floor to consumers’ hands. Sustainability, the circular economy (the life-cycle of products), upcycling, these are ways of thinking about how we use and reuse products. Nature doesn’t waste a thing. Neither should we (Ellen McArthur Foundation, 2017).

I’d like to close with a few more thoughts on the issue from researcher, Kelly Somers:

“I have a passion for this planet, and I consider it an honor that my personal interests and love of nature have become

a career for me. I try not to *preach* too much to my friends and family but I do take the opportunity to teach where appropriate. I was recently taking an evening walk along the beach down the Shore and I cringed when I watched about 20 balloons being released right there on the beach. I realized there is so much more education and outreach that needs to be done.”

It’s true, so where do we start? First, we need to get more women involved in STEM. Actually, not just women, but everyone. Next, we need to end the war on science as it has gone on most everywhere for far too long. Science is our friend. It has saved us from plagues and pestilence and pandemics, and it can save us from plastics, so let’s call a truce. Finally, let’s acknowledge our short-comings — no time for blame now — and work together to start sustainably anew. As I tell my kids all the time, we stand on the backs of all those men and women who came before us, paving our way and opening wide the doors of equal opportunity. We owe them a huge debt of gratitude and it would behoove us not only to remember from whence we came but to start paying it forward.

So ladies and gents, let’s shift our priorities, push back a little, and then a little more. We are the gatekeepers of the future, not just because without us there would be no more babies, but because every decision we make impacts the lives of all those who follow. So use your purchasing power. Vote with your wallet. Choose natural. Choose sustainable. Choose replenish-able. And choose to do it starting *now*, because the future needs our help, and we can affect that future with every single choice we make.

Let’s begin. There’s not a moment to waste.

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