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Assembly
California Legislature
ASSEMBLY COMMITTEE ON
ENVIRONMENTAL SAFETY
AND TOXIC MATERIALS
BILL QUIRK, CHAIR
ASSEMBLYMEMBER, TWENTIETH DISTRICT

INFORMATIONAL HEARING

Microplastics in our water and environment: understanding a growing pollution source

To:	Members of the Assembly Environmental Safety & Toxic Materials Committee
From:	Assemblymember Bill Quirk, Chair
Subject:	Overview of microplastic pollution, what it is, where it comes from, and strategies for preventing its dispersal in the environment.
Date:	Tuesday, March 2, 2021

Introduction

Plastic pollution is a persistent and growing source of pollution in California that impacts our natural resources and public health. California communities are estimated to spend more than $428 million annually to clean up and control plastic pollution, yet the efforts are not enough to stymie this exponentially growing source of contamination. Plastics, and their microparticle offspring, known as microplastics, are prevalent nearly everywhere, including in our homes, workplaces, bodies, drinking water, and environment. The intake of microplastics by humans is, by now, evident[i], and studies have found microplastics in drinking water, salt, honey, and other food sources. The ubiquity of plastics creates unprecedented challenges to regulators, engineers, and scientists as they grapple with this potential human health threat and environmental pollution source.

The goals for today's hearing are:

1) Hear an overview of microplastics -- what they are, where they come from, and how they are measured and identified;

2) Discuss the known impacts of microplastics on human health and the environment; and,

3) Discuss the various strategies for preventing, remediating, and addressing this source of exposure and pollution.

Microplastics

Plastics are a group of materials, either synthetic or naturally occurring, that can be shaped when soft and then hardened to retain the given shape. Plastics are polymers, which are substances made of many repeating units.[ii] Common uses of plastics include tough and lightweight beverage bottles made of polyethylene terephthalate (PET), flexible garden hoses made of polyvinyl chloride (PVC), insulating food containers made of foamed polystyrene, and shatterproof windows made of polymethyl methacrylate[iii].

When plastic bags, bottles, take-out boxes, wrappers, and other plastic items enter waterways, they are broken down into tiny particles by ultraviolet radiation and the water's motion. When clothes made from synthetic materials, such as polyester and nylon, are washed, they shed tiny fibers that evade capture by wastewater treatment facilities and are released into surface waters, according to a review of available data by the outdoor clothing and gear company, Patagonia, and the Bren School of Environmental Science and Management at the University of California at Santa Barbara. Plastics smaller than 5 millimeters in size are called microplastics.

Microplastics come in different shapes (fragments, films, and fibers), sizes, and materials (such as polystyrene and polyester). For example, single use plastic water bottles are commonly made from polyethylene and break down into microplastic fragments, while clothes made from polyester, nylon, and other synthetics shed microplastic fibers.

The 2017 study *Primary Microplastics in the Oceans* by the International Union for Conservation of Nature (J. Boucher, D. Friot, 2017) found that 9.5 million tons of plastic waste flow into the ocean each year and, according to the United States Environmental Protection Agency, microplastics are commonly found in freshwater systems as well.

Plastic never truly fully biodegrades; instead, it physically breaks down by ultraviolet radiation and wave action into smaller and smaller pieces. Microplastics are found worldwide, even in places considered untouched by anthropogenic pollution. Plastics have been found in the digestive tracts of marine organisms ranging from zooplankton to whales, and microplastics have been found in drinking water and food, including shellfish, salt, beer, and honey.

The State Water Resources Control Board (State Water Board) recently defined "microplastics" with regards to drinking water pursuant to Senate Bill 1422 (Portantino, Chapter 902, Statutes of 2018) as follows[iv]:

> 'Microplastics in Drinking Water' are defined as solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1 nm and less than 5,000 micrometers (µm). Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.
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> *Evidence concerning the toxicity and exposure of humans to microplastics is nascent and rapidly evolving, and the proposed definition of 'Microplastics in Drinking Water' is subject to change in response to new information. The definition may also change in response to advances in analytical techniques and/or the standardization of analytical methods.

This is the first official regulatory definition of microplastics in drinking water in the world, and it is the starting point for future policy and regulatory discussions.

Sources of microplastics

Microfibers

Over time, textiles, including those made of synthetic fibers (such as polyester, nylon, microfiber, acrylic, and spandex) shed small fibers through the normal process of wear, tear, and washing. These fibers are typically classified as microfibers when they are shorter than five millimeters. While all textiles seem to shed, studies conducted by academic laboratories and by Patagonia in collaboration with the University of California at Santa Barbara (Patagonia Study), indicate that many factors determine how much a textile sheds when washed. Currently, washing machines are not equipped to filter out microfibers and up to 40% of microfibers pass through wastewater treatment plants. Therefore, large quantities (about 4 billion microfibers, an estimated 81 kilograms, per day at one treatment plant studied) are discharged into the environment.

Wastewater

Researchers have recently determined that billions of microplastics flow through the San Francisco Bay Area's 40 wastewater treatment facilities each year.

Even if wastewater treatment plants could filter out all microfibers, they may still make their way into the environment through sewage sludge applications. The article, *Conversion and removal strategies for microplastics in wastewater treatment plants and landfills,* published in Chemical Engineering Journal claimed that wastewater treatment plants sequester most (80-99.9%) microplastics into sludge.[v]

To better understand microplastics in wastewater, the Southern California Coastal Water Research Project (SCCWRP) is coordinating a microplastics evaluation study with the California Association of Sanitation Agencies of influent and effluent at 6-12 wastewater facilities. The research, which will commence sometime this summer, will assess the processes at each facility, including a look at the sewage sludge.

Clothing Dryers

Aerial transport of microplastics from dryer exhaust may be a significant pathway into the outdoor environment. The results of the study, *Electric clothes dryers: An underestimated source of microfiber pollution*[vi] (K. Kapp, R. Miller, 2020) establish that electric clothes dryers are contributing a potentially large volume of synthetic and non-synthetic microfibers from clothing and home textiles into our environment, demonstrating a need to develop and implement strategies/equipment that reduce microfiber pollution from dryers.

Tires

Plastics from tires are proving to be a significant source of microplastic pollution according to the San Francisco Estuary Institute (SFEI), in their 2019 study, *Understanding Microplastic Levels, Pathways, and Transport in the San Francisco Bay Region* (Microplastics Study). The study intimates that rainfall washes more than 7 trillion pieces of microplastics, much of it tire particles left behind on streets, into San Francisco Bay each year — an amount 300 times greater than what comes from microfibers washing off polyester clothes, microbeads from beauty products, and the many other plastics washing down our sinks and sewers.

Litter/illegal dumping

The United States is the top generator of plastics waste globally, and is among the top contributors to plastic waste inputs into the coastal environment.[vii] Plastic pollution comes mostly from high rates of waste generation, illegal dumping, and mismanagement, including in countries to which US waste is exported.

Littering and illegal dumping contribute approximately one million metric tons of plastic waste to the environment within U.S. borders. Up to another one million metric tons are estimated to enter the environment in countries that import and process waste collected in the US for recycling.

In California, litter gets swept up in stormwater runoff and, if not captured, enters our rivers, coastlines, and oceans.

Stormwater

Using an existing stormwater model developed for other contaminants, SFEI in its Microplastics Study estimated the annual discharge of microparticles via stormwater from small tributaries to be 11 trillion microparticles to the San Francisco Bay. Approximately two thirds of these microparticles were estimated to be plastic, yielding an estimated annual discharge of 7 trillion microplastics per year. This estimate of microplastic load is approximately 300 times greater than the estimated annual discharge from all wastewater treatment plants discharging into San Francisco Bay, therefore, implying that stormwater is the primary source of microplastic pollution.

Aerial depositions

Recent research on aerial depositions of microplastics found that high altitude winds and rain storms circulate microplastics through the environment to remote areas, such as national parks and even the arctic. The plastic particles identified include tiny fibers, likely from clothes, carpets, and other textiles and unidentified, brightly colored spherical microparticles that are likely components of paints that might be released to the atmosphere during spray painting. The research found atmospheric weather patterns are depositing about 132 pieces of microplastics on every square meter of wilderness each day, which adds up to more than 1,000 tons of plastic per year across national parks and other protected areas of the western United States—the equivalent of 300 million plastic water bottles. (J. Brahney, M**.** Hallerud, E. Heim, M. Hahnenberger, S. Sukumaran, 2020, Plastic Rain in Protected Areas of the United States)

Much of these microplastic particles may be historic plastic pollution from decades ago; the microplastics may have first settled in farm fields, or deserts, or the ocean and then have been picked up again by winds as part of a global "plastic cycle."

Microplastics in drinking water supplies and the environment

Drinking water

Researchers at the State University of New York and the University of Minnesota tested 159 drinking water samples from cities and towns across five continents. Eighty-three percent of those samples worldwide contained microplastics. In the United States, 94% of the samples contained microplastics, including a sample collected from the United States Environmental Protection Agency headquarters. Two studies commissioned by Orb Media found microplastics in tap water and bottled water in more than 80% of samples taken from around the world.

California Coastkeeper Alliance has reported that 92% of bottled and 82% of tap water in California are contaminated by microplastics; therefore, humans are ingesting microplastics when they drink and eat foods prepared by using tap or bottled water.

Groundwater

Microplastics contaminate the world's surface waters, yet scientists have only just begun to explore their presence in groundwater systems. A 2019 study from the University of Illinois at Urbana-Champaign reported a finding that 16 of 17 groundwater samples from fractured limestone aquifers contained microplastic particles.

In California, the State Water Board reported in their June 3, 2020, Proposed Definition of 'Microplastics in Drinking Water' that available information indicates groundwater wells are likely to contain very low (if any) levels of microplastics (Mintenig et al. 2019). Very few studies have measured microplastics in groundwater, although very small microplastics were not measured, and there is skepticism regarding the validity of the findings of microplastics in groundwater.

Water bodies and aquatic life

Microplastics are ingested by marine life from coral to remote deep-sea fish and from mollusks to whales. In a 2015 study, microfibers comprised 80% of the debris found in fish and shellfish sampled in local markets in Half Moon Bay, California. In species including crabs, ingesting microplastics reduces food consumption, decreasing the overall energy budget available for growth. In fish, microplastics can cut the intestinal track and cause tissue death and inflammation. Fish fed microplastic fragments, which had absorbed chemicals, bioaccumulated these chemicals and sustained liver damage. The impact of ingesting microparticles on individual organisms and on whole ecosystems are current areas of scientific research.

The SFEI Microplastics Study also found that at least 38% of fish sampled from the San Francisco Bay had consumed microparticles. The estimated average number of microplastics was between 0.2 and 0.9 non-fiber microplastics per fish and between 0.6 and 4.5 plastic fibers per fish. While fibers were detected in all fish from the Bay regardless of species, non-fiber microplastics were more frequently detected in topsmelt compared to anchovies. The microplastic counts and detection frequencies in the Bay were comparable to counts reported in many other locations. These results indicate that microplastics are entering Bay food webs. Microplastics have been shown to transfer up food chains and cause adverse effects in fish, but the magnitude and types of effects are difficult to predict because of the diversity of microplastic morphologies and compositions.

Microplastics and human health

Human ingestion

People are exposed to microplastics through a number of routes including seafood consumption, tap water, bottled water, household dust, and inhalation of airborne microfibers. Bioaccumulation of toxins from microplastics in seafood has raised concerns that consumption may be a route of exposure to toxins as well as plastic.

Microplastics have also been detected in beer, salt, honey, and in other foodstuffs, but the question has to be asked: Are they harmful to people?

There are many data gaps and unverified analytical methodologies for testing microplastics in food, therefore, it is not definitively known what effect these small particles have on human health. What is known, however, is that plastics containing chemicals like Bisphenol A and phthalates, have known health hazards, such as endocrine disruption and reproductive toxicity.

One major unknown is the plastic humans are ingesting via food. Plants can uptake and accumulate sub-micron sized microplastics, causing reduced growth and diminished food production[viii]; however, the transport/accumulation into the edible portions of plants, and bioaccumulation into animals has not been thoroughly investigated. More information is needed about the uptake in plants and biomagnification in animals to understand how it impacts humans up the food chain.

Microplastics in the human placenta

The January 2021 study, *Plasticenta: First evidence of microplastics in human placenta* (A. Ragusa, et al) is the first study revealing the presence of pigmented microplastics and, in general, of anthropogenic particles in human placenta. The study's authors analyzed six human placentas to evaluate the presence of microplastics and found microplastics in all placental portions: maternal, fetal, and amniochorial membranes. The study's authors note that we do not know how microplastics reach the bloodstream and whether they come from the respiratory system and/or the gastrointestinal system, and conclude, "Due to the crucial role of placenta in supporting the [fetus] development and in acting as an interface between the latter and the external environment, the presence of exogenous and potentially harmful (plastic) particles is a matter of great concern. Possible consequences on pregnancy outcomes and [fetus] are the transgenerational effects of plasticizer on metabolism and reproduction (Lee, 2018). Further studies need to be performed to assess if the presence of [microplastics] in human placenta may trigger immune responses or may lead to the release of toxic contaminants, resulting harmful for pregnancy."[ix]

While there is cause for concern, there is so far no direct evidence yet that this emerging problem directly impacts human health.

In 2018, the Legislature enacted SB 1263 (Portantino, Chapter 609, Statutes of 2018) to broaden the scope of work of the Ocean Protection Council (OPC) to work in collaboration with the State Water Board and the Office of Environmental Health Hazard Assessment to assess the risks marine microplastics may pose to human health. Under that law, the OPC is required to develop and submit a statewide Microplastics Strategy to the legislature by the end of 2021, with a follow up progress report due at the end of 2025.

Pollution prevention strategies

Reduction of single-use disposable plastics

The most efficient tactic of reducing microplastic exposure and pollution will be getting at the roots: source reduction. By reducing the prevalence of single-use disposable plastics, plastic packaging, and plastic litter, plastic pollution can be dramatically reduced, thereby minimizing future generation of microplastics.

In 2016, the OPC funded a pilot project to "unpackage" Alameda. Through this project, Clean Water Fund worked with 80 to 100 businesses in Alameda to reduce their reliance on single-use disposable food packaging. This project piloted changes in institutional purchasing to reduce the prevalence of single-use foodware that typically becomes plastic pollution. Overall, the 80 businesses that participated are estimated to eliminate more than 6 million pieces of single-use foodware annually, preventing more than 64 thousand pounds of waste each year. Collectively these businesses are estimated to save more than $139,000 annually.

Successes like Unpackage Alameda are reassuring; however, while actions can be taken to reduce future pollution, historic microplastics are plaguing our environment and drinking water supplies, and few (if any) treatment technologies exist to remediate them.

Washing machine filters

The public relations around microfibers has grown, and so has consumer awareness of the problem. Therefore, various devices have been designed to capture microfibers released from clothing during the washing cycle, including the Cora Ball and Patagonia's Guppyfriend.

In the study, *The efficiency of devices intended to reduce microfibre release during clothes washing*, (I. Napper, A. Barrett, R. Thompson, 2020) six different devices ranging from prototypes to commercially available products were compared for efficacy in capturing microfibers. The study found that consumer washing machine filter devices range in efficiency for removing microplastics by 21% to 78%, but concluded that despite some potentially promising results, it is important to recognize that fibers are also released when garments are worn in everyday use. Researchers and industry need to continue to collaborate to better understand the best intervention points to reduce microfiber shedding, by considering both product design and fiber capture.

Plastics recycling

An estimated 35 million tons of waste are disposed of in California's landfills annually. Plastic accounts for around 12% of California's disposed waste stream -- more than 4.5 million tons. Three of the four most prevalent types of plastic in California's landfills are forms of plastic film, which includes items like agricultural mulch film, pallet wrapping, grocery bags, and trash bags. Recycling figures are harder to estimate, as California has only recently begun collecting data from recycling facilities, but it appears that less than 15% of the plastic generated in California is recycled.

The Assembly Natural Resources Committee reported in its November 16, 2020, hearing memo that recycling plastic into new products is helpful, but not a solution. Recycling is generally only feasible for some of the more common, and least toxic, forms of plastic, like the kind used for beverage containers. Many forms of plastic are commonly treated with toxic flame retardants and plasticizers, which make them difficult to recycle. The abundance and variety of the types of plastic in our recycling system make it difficult to sort, and high contamination rates in bales of recycled plastic have caused many countries, including China, to stop accepting recycled plastic from the United States unless it meets stringent contamination rates. The most significant challenge to recycling remains its low scrap value and lack of market demand. When oil prices are low, recycled plastic cannot compete with new plastic in the marketplace.

Water recycling

Like many other recycled materials, water can be reused. Recycled water has been used for many years in many different ways. Some early uses include using recycled water in place of potable water, such as for landscape irrigation and as a barrier for seawater intrusion. More and more recycled water is being looked at as an option to provide additional drinking water. Many water agencies are using recycled water to recharge groundwater aquifers as a source of drinking water. Eventually, as science and safeguards allow, many see the ultimate use of recycled water as a direct use for drinking.

Capturing and treating stormwater and treating and reusing wastewater helps to more efficiently use our limited freshwater supplies, and can provide opportunity to filter out plastic before the water goes back into the environment.

Changing consumer behavior

If knowledge is power, then information is also vital. When consumers are informed, they are better equipped and more apt to respond with changes in behavior. When consumers are informed writ large, they have purchasing power that can compel manufacturers and retailers to respond to their demands. Greater media coverage on climate change, for instance, has led to changes in consumer demands for hybrid and electric vehicles, among other things. As it relates to plastics use, news coverage of California's waste generation and China's rejection of California's "recyclables" helped spur a galvanization around banning single use plastic bags in jurisdictions across the state; social media criticism of single-use coffee pods; and, plastic water bottle manufacturers reducing the weight of their plastic bottles to demonstrate use of less plastic.

Incentives have long been used to encourage consumer behavior. California's Bottle Bill, for example, has a 5-cent and 10-cent redemption value (CRV) on bottles and cans that consumers receive back when they return their bottles and cans for recycling. The CRV has been so successful that the state's recycling rates exceed 80% for the covered beverage containers.

Policy changes can also compel changes in human behavior. Effective March 27, 2019, the City of Berkeley's Single User Foodware and Litter Reduction Ordinance went into effect to reduce the use and disposal of single use foodware, including cups, lids, utensils, clamshells, and other disposables. The intent of the ordinance is to effect behavioral change by assisting local businesses shift away from single use products toward reusable foodware.

Making desired behavior convenient is another tactic for achieving change. California enacted a state law to allow consumers to return their used paint cans, whether full or empty, to retailers that sell paint in order to make it more convenient to properly dispose the old cans than trekking out to a household hazardous waste facility.

Conclusions

Much is known about the existence of microplastics and where they can be found, but much more data is needed to close the information gaps on what their presence means to our water supplies, aquatic environments, soil, agriculture, and human health. More specifically, we need to better understand the sources of microplastics in the air; the full scope of human consumption of microplastics in food, air, and water; and, the human health impacts of microplastics. Preliminary research on human cells and rodents suggests that microplastics may cause DNA damage, inflammation, neurotoxic effects, and metabolic effects. But more work is needed to understand if these effects are seen when humans are exposed at levels normally found in the environment. Microplastics are challenging to study because they vary widely in size and chemical composition, so many findings are limited by the type and size of microplastics included in the study.

To fill those knowledge gaps, consistent methodologies and protocols for sampling and testing need to be developed and certified.

To date, most of the solutions focus on mitigating the release of microplastics into the environment. More research is needed to determine if additional strategies are required to reduce human exposure to microplastics (e.g. through drinking water treatment).

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[i] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7068600/

[ii] https://www.sciencehistory.org/science-of-plastics

[iii] https://www.britannica.com/science/plastic

[iv] https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2020/rs2020_0021.pdf

[v] https://www.sciencedirect.com/science/article/abs/pii/S1385894720328436

[vi] https://doi.org/10.1371/journal.pone.0239165

[vii] https://advances.sciencemag.org/content/6/44/eabd0288

[viii] https://www.nature.com/articles/s41565-020-0767-5

[ix] https://www.sciencedirect.com/science/article/pii/S0160412020322297