Written Statement of
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Before The
Senate Committee on Environment and Public Work
Subcommittee on Chemical Safety, Waste Management, Environmental Justice, and Regulatory Oversight and the Subcommittee on Fisheries, Water, and Wildlife

Thank you Chairmen Merkley and Padilla and Ranking Members Lummis and Mullin for the opportunity to testify today on the potential for microplastics in drinking and wastewater to have possible repercussions for environmental and human health. I am pleased to provide testimony today on the role university-based research can play in providing the committee with information and tools to better understand this issue.

I am an Associate Professor in the College of Agricultural Sciences at Oregon State University (OSU) and have been conducting research on microplastics and plastic pollution for nearly a decade. As part of these efforts, I have contributed to the understanding of occurrence in the environment in water, sediment and biota on both coasts of the United States, and have also conducted research and published findings on the toxicity and hazard of microplastics to aquatic organisms. We share this work with stakeholders and collaborators through the NSF-funded Pacific Northwest Consortium on Plastics. I have also contributed to regulatory efforts in the State of California on their recent microplastics strategy and plans to monitor drinking water for microplastics statewide, as well as contributing to ongoing efforts on developing standardized protocols for microplastics sampling and quantification. My group's research efforts have been supported at the federal level by the NSF, EPA, NOAA, and the DOE.

Microplastics in Drinking and Wastewater

The issue of plastic pollution has become one of the greatest environmental challenges of the Anthropocene. It has also emerged as one of the world's most expensive problems, with the economic impact of this pollution to fishing, tourism, and shipping estimated at $13 billion annually (Lau et al. 2020) and estimated healthcare costs in the U.S. at a staggering $249 billion in 2018 due to plastics-associated chemical exposures (Trasande et al., 2024). Without system-wide change, rates of global production and use will continue to increase at approximately 4% annually (Geyer et al., 2022), and a doubling of mismanaged plastic waste is predicted by 2050 (Lau et al., 2020). Therefore, it is not surprising that the fragmentation of these products into microplastics is of substantial concern to the nation's

water treatment sector, where microplastic contamination is widely documented during the treatment of wastewater from households as well as in the production of drinking water (Acarer, 2023; Carr et al., 2016; Geyer et al., 2022).

Microplastics are now broadly defined by the State of California as a solid polymeric material, to which chemical additives or other substances may have been added, which are particles having at least three dimensions that are greater than 1 nanometer (nm) and less than 5,000 micrometers (μm) (CA Water Boards 2020). These ranges are approximately from one millionth of a millimeter to 5 millimeters and includes a vast diversity of particle types encompassing fragments, fibers, films, foams, pellets, and spheres (Rochman et al., 2019), the formulation of which is estimated to use upwards of 13,000 chemicals as additives, fillers, dyes, etc. (UNEP 2023). Microplastics are widely documented to harm to aquatic and terrestrial organisms, slowing growth, altering behavior, and causing reproductive disruption (Cui et al., 2022; Cunningham et al., 2022; Siddiqui et al., 2022; Thornton Hampton et al., 2022). They also can cause adverse effects in mammals (Coffin et al., 2022; Prata, 2023; Szule et al., 2022). While research on human impacts from these particles is in earlier stages, microplastic particles presence is confirmed in the human heart, placenta, and lung tissues and they also circulate within the human bloodstream (Leslie et al., 2022; Lu et al., 2022; Persiani et al., 2023; Ragusa et al., 2021). Comparisons are now being made to the health effects caused by particulate matter and asbestos (Wieland et al., 2022).

Microplastics in wastewater and drinking water originate from multiple sources. In the gray water processed as influent to wastewater treatment plans, this includes the shedding of synthetic microfibers from textiles washed in domestic households and industrial facilities as well as the breakdown of plastic parts in dishwashers and washing machines, the fragmentation of plastic dishes, cups, lids, and cutlery, and detergents either containing or coated with plastics (Carr et al., 2016; Geyer et al., 2022; Sol et al., 2023). The washing of one synthetic garment alone can result in the shedding of over 100,000 microfibers, and on average a typical load of laundry washed in a machine lacking filtration creates upwards of 9 million microfibers (Figure 1) (Gao et al., 2023; Geyer et al., 2022). Dishwashers, which are present in 80% of households in North America, generate between 1067-1468 microplastics during a typical intensive washing cycle run at high heat. It is estimated that a town of approximately 220,000 residents could emit over 300 million microplastics from dishwashing alone in a single day (Sol et al., 2023). The burden of dealing with these microplastics is shifted to wastewater treatment plants, which can remove a majority from treated effluent, only to retain up to 99% of the particles in sludge and eventual biosolids.

These biosolids are then commonly applied to agricultural fields as fertilizers, allowing for the plastic fragments and microfibers they contain to be remobilized or to contaminate soils on which crops are grown and are connected to terrestrial ecosystems, also now documented to be widely contaminated with microplastics (Christian & Köper, 2023; Gao et al., 2023). Some of these particles are washed back into waterways with precipitation and irrigation, starting the cycle of pollution anew (Figure 2).

While drinking water in the US tends to contain fewer microplastics in comparison to wastewater, the U.S. has among the highest prevalence of microfibers in its drinking water globally (Figure 3, Trasande et al., 2024). Furthermore, a 2018 study found that in an analysis of 150 tap water samples collected from different parts of the world, that the USA had the highest number of particles detected per liter (33.9 microplastics / liter; Kosuth et al., 2018). While microplastic contamination of drinking water is concerning, given some of the results from studies on mice and rats, typically used as models for human heath, showing the potential for impacts to reproductive and microbiome health (Coffin et al., 2022; Szule et al., 2022), far less is known about the occurrence and effects of long-term exposure to even tinier particles: nanoplastics (one millionth of a millimeter). It is likely that drinking water, like bottled water was recently shown to, contains high levels of microplastic's smaller counterpart, but analytical approaches for detecting smaller size fractions are currently expensive and limited (Qian et al., 2024). However, since drinking water tends to contain smaller particles due to treatment processes that capture larger microplastics, these smaller particles that have the capability to translocate (Prata, 2023; Wright & Kelly, 2017) are predominant in the water families depend on daily in their homes for drinking and cooking.

Access to clean water for drinking, cooking, and other household activities is a basic human right (UN 2010, Resolution 64/292). However, our inability to prevent the pollution of water from contaminants of emerging concern, which now include microplastics, threatens the health of people of every age and from every walk of life. Experts in the field agree that source reduction is desperately needed, but with plastic use embedded deeply in the fabric of our daily lives and the subsequent shedding of microplastics from plastic products being difficult to control, this is a challenge that must be addressed across multiple sectors simultaneously for progress to be made in reducing microplastic contamination. Given the accumulating evidence that microplastics continually degrade into smaller and smaller sizes, and that these smaller microplastics and nanoplastics can move from the gut to other organs and tissues within the human body (Figure 4; Prata, 2023), eliciting inflammation and cellular toxicity with the potential for causing fibrosis and

even myocardial damage (Persiani et al., 2023), a prudent next step would be to take action to limit their presence in our waterways and bodies. Potential solutions include requiring microfiber filters on washing machines, which is already done in countries such as Japan that rely heavily on septic systems (https://www.forbes.com/sites/ariannajohnson/2023/09/27/). Furthermore, catchments and rain gardens significantly reduce plastic pollution from stormwater run-off as it enters drains or combined sewer systems (Werbowski et al., 2021).

Our nation's waterways are intended to be protected by the Clean Water Act, which as amended in 1972, established a framework for the regulation of pollutant discharges to waters in the United States. This gave the EPA authority to implement and enforce pollution control programs such as the National Pollutant Discharge Elimination System. However, the CWA only applies to clearly defined point sources, and thus far has not been used to regulate the discharge of microplastics into water bodies. Given that microplastics or their precursors could be defined as originating from point sources at different stages within the plastics life cycle: in particular the emissions of plastic pellets (nurdles) from production facilities (Figure 5; Tunnell et al., 2020), discharge of microplastic fibers and fragments in the form of effluent or biosolids from wastewater treatment plants, or the recent vinyl chloride spill at the Pennsylvania / Ohio border; the CWA provides the most direct route for potentially regulating microplastics and related products from these documented and now common point sources. Longer term solutions are greatly needed, and include better waste management strategies such as improved recycling, chemical simplification and a move towards globally touted approaches for circularity and safely and sustainably designed materials and products.

Summary

This testimony summarizes the current state of the science on microplastic presence in drinking and wastewater, as well as what is known about potential impacts to ecosystems and to human health. Microplastics are an emerging contaminant of concern and thus this is an area of highly active and ongoing research in which findings that may influence our approach to handling this form of particulate pollution are being published on a monthly, if not more frequent, basis. Plastic pollution is of global concern and I appreciate that this issue is being explored and considered for further potential policy development. I thank the Committee and Subcommittees for the opportunity to testify and for their consideration of the information and data included in my written and spoken testimony. As a researcher, it is encouraging to see findings potentially translated to application and to play a role in the legislative thought process. I would be pleased to offer further information as needed, and to answer any questions you may have.

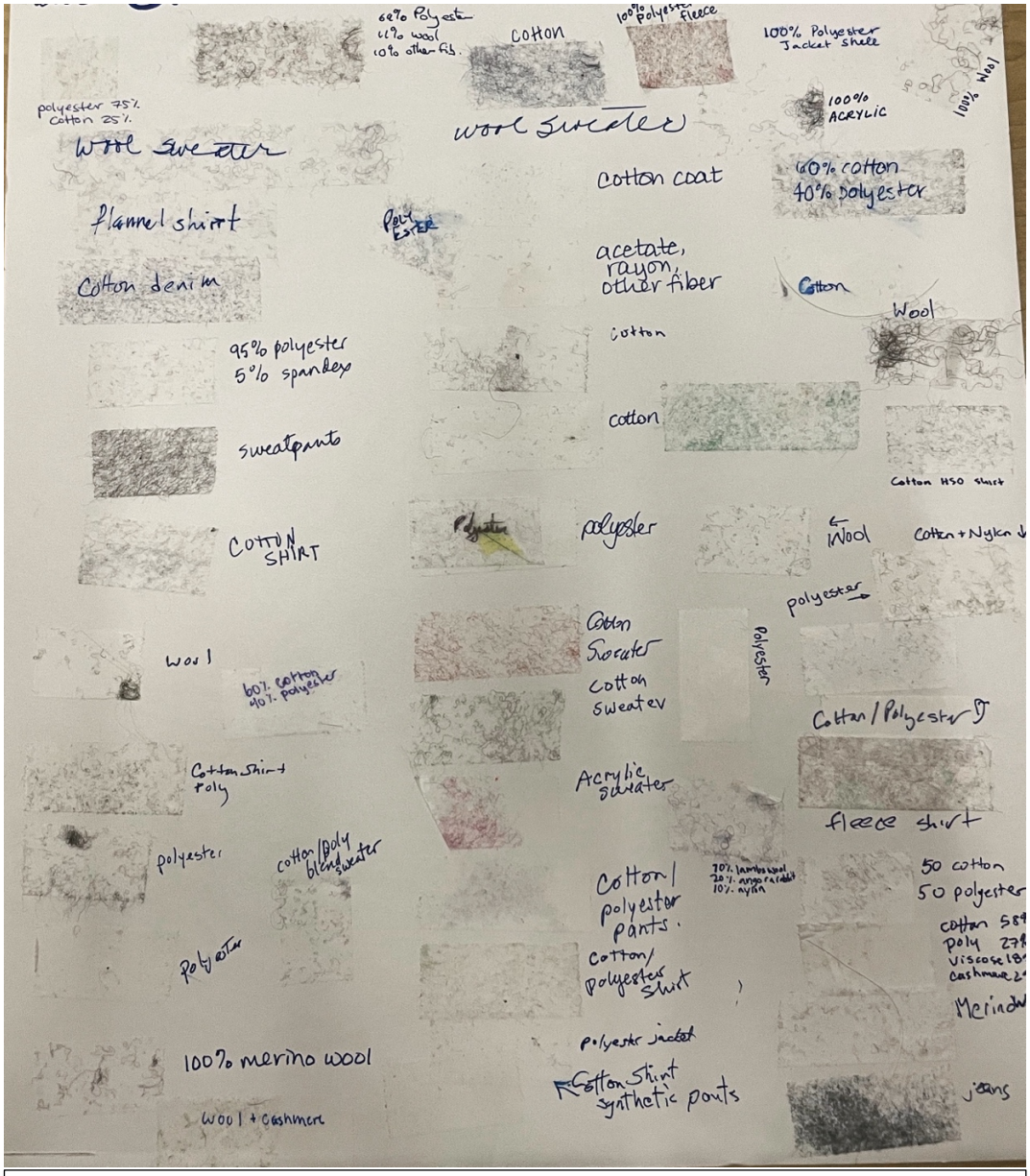


Figure 1. Fibers removed with small strips of scotch tape from the clothing of ~40 audience members at an Oregon State University event. Composition was recorded from clothing tags. Credit: S. Brander

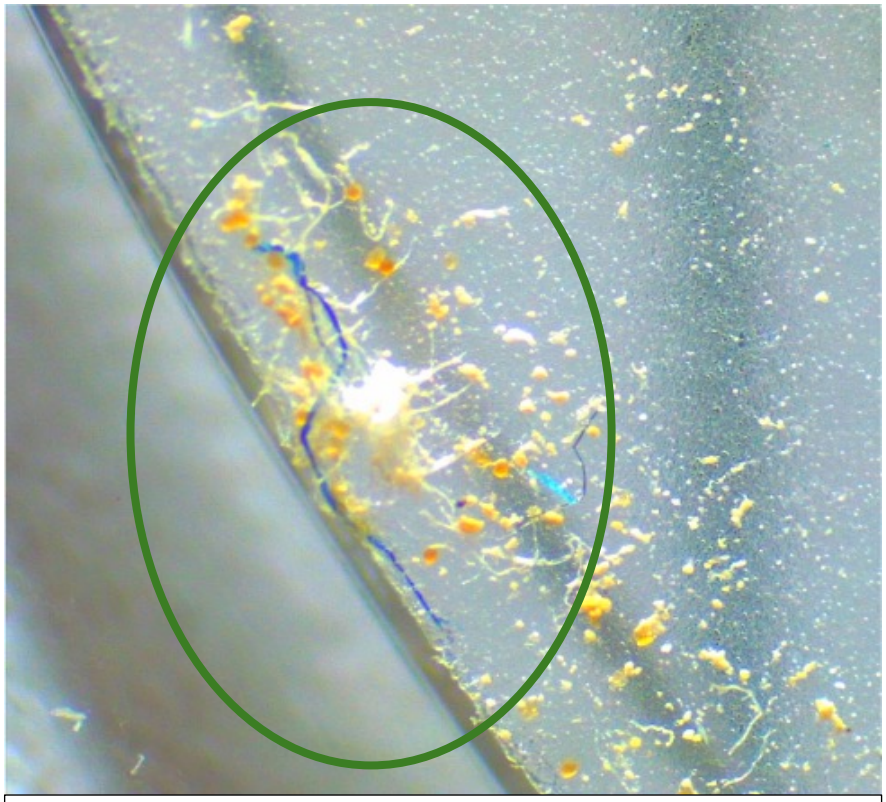


Figure 2. Blue, white, and clear fibers extracted from treated wastewater effluent sourced from an Oregon treatment plant, Leica stereoscope 16x. Credit: S. Arriola, OSU student

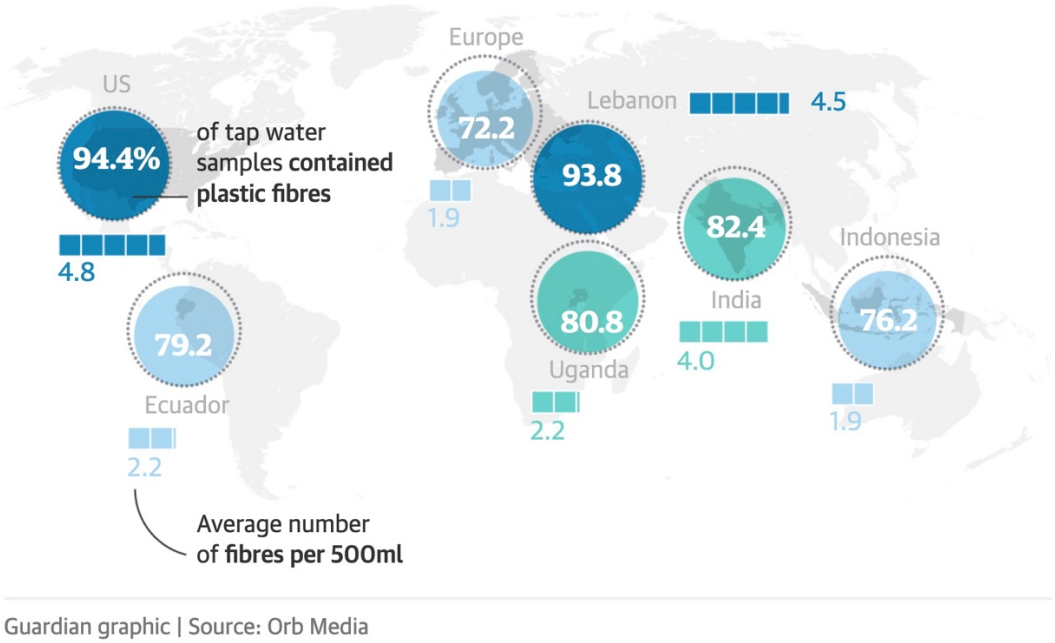


Figure 3. Microfibers detected in tap water samples globally, 2017. Credit: Orb Media, The Guardian

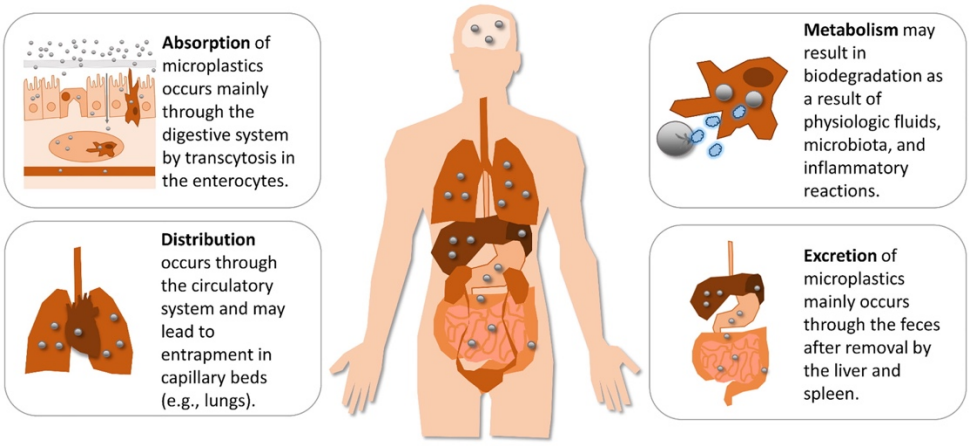


Figure 4. Summary of the pharmacokinetics of microplastics in the human body. Reprinted from Prata 2023, http://doi.org/10.1080/10643389.2023.2195798



Figure 5. Graphical abstract, *Measuring plastic pellet (nurdle) abundance on shorelines throughout the Gulf of Mexico using citizen scientists*, reprinted from Tunnel et al. 2020.

References Cited

Acarer, S. (2023). Abundance and characteristics of microplastics in drinking water treatment plants, distribution systems, water from refill kiosks, tap waters and bottled waters. *Science of The Total Environment*, 163866.

Carr, S. A., Liu, J., & Tesoro, A. G. (2016). Transport and fate of microplastic particles in wastewater treatment plants. *Water Research*, *91*, 174–182. https://doi.org/10.1016/j.watres.2016.01.002

Christian, A. E., & Köper, I. (2023). Microplastics in biosolids: A review of ecological implications and methods for identification, enumeration, and characterization. *Science of The Total Environment*, *864*, 161083. https://doi.org/10.1016/j.scitotenv.2022.161083

Coffin, S., Bouwmeester, H., Brander, S., Damdimopoulou, P., Gouin, T., Hermabessiere, L., Khan, E., Koelmans, A. A., Lemieux, C. L., Teerds, K., Wagner, M., Weisberg, S. B., & Wright, S. (2022). Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. *Microplastics and Nanoplastics*, *2*(1), 12. https://doi.org/10.1186/s43591-022-00030-6

Cui, W., Gao, P., Zhang, M., Wang, L., Sun, H., & Liu, C. (2022). Adverse effects of microplastics on earthworms: A critical review. *Science of the Total Environment*, *850*, 158041.

Cunningham, B., Harper, B., Brander, S., & Harper, S. (2022). Toxicity of micro and nano tire particles and leachate for model freshwater organisms. *Journal of Hazardous Materials*, *429*, 128319.

Gao, Z., Chen, L., Cizdziel, J., & Huang, Y. (2023). Research progress on microplastics in wastewater treatment plants: A holistic review. *Journal of Environmental Management*, *325*, 116411.

Geyer, R., Gavigan, J., Jackson, A. M., Saccomanno, V. R., Suh, S., & Gleason, M. G. (2022). Quantity and fate of synthetic microfiber emissions from apparel washing in California and strategies for their reduction. *Environmental Pollution, 298*, 118835. https://doi.org/10.1016/j.envpol.2022.118835

Kosuth, M., Mason, S. A., & Wattenberg, E. V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. *PLOS ONE*, *13*(4), e0194970. https://doi.org/10.1371/journal.pone.0194970

Lau, W. W. Y., Shiran, Y., Bailey, R. M., Cook, E., Stuchtey, M. R., Koskella, J., Velis, C. A., Godfrey, L., Boucher, J., Murphy, M. B., Thompson, R. C., Jankowska, E., Castillo Castillo, A., Pilditch, T. D., Dixon, B., Koerselman, L., Kosior, E., Favoino, E., Gutberlet, J., … Palardy, J. E. (2020). Evaluating scenarios toward zero plastic pollution. *Science*, *369*(6510), 1455–1461. https://doi.org/10.1126/science.aba9475

Leslie, H. A., van Velzen, M. J. M., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. *Environment International*, *163*, 107199. https://doi.org/10.1016/j.envint.2022.107199

Lu, K., Zhan, D., Fang, Y., Li, L., Chen, G., Chen, S., & Wang, L. (2022). Microplastics, potential threat to patients with lung diseases. *Frontiers in Toxicology*, *4*, 958414.

Persiani, E., Cecchettini, A., Ceccherini, E., Gisone, I., Morales, M. A., & Vozzi, F. (2023). Microplastics: A Matter of the Heart (and Vascular System). *Biomedicines*, *11*(2), 264.

Prata, J. C. (2023). Microplastics and human health: Integrating pharmacokinetics. *Critical Reviews in Environmental Science and Technology*, *53*(16), 1489–1511. https://doi.org/10.1080/10643389.2023.2195798

Qian, N., Gao, X., Lang, X., Deng, H., Bratu, T. M., Chen, Q., Stapleton, P., Yan, B., & Min, W. (2024). Rapid single-particle chemical imaging of nanoplastics by SRS microscopy. *Proceedings of the National Academy of Sciences*, *121*(3), e2300582121.

Ragusa, A., Svelato, A., Santacroce, C., Catalano, P., Notarstefano, V., Carnevali, O., Papa, F., Rongioletti, M. C. A., Baiocco, F., Draghi, S., D'Amore, E., Rinaldo, D., Matta, M., & Giorgini, E. (2021). Plasticenta: First evidence of microplastics in human placenta. *Environment International*, *146*, 106274. https://doi.org/10.1016/j.envint.2020.106274

Rochman, C. M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., Athey, S., Huntington, A., McIlwraith, H., Munno, K., De Frond, H., Kolomijeca, A., Erdle, L., Grbic, J., Bayoumi, M., Borrelle, S. B., Wu, T., Santoro, S., Werbowski, L. M., … Hung, C. (2019). Rethinking microplastics as a diverse contaminant suite. *Environmental Toxicology and Chemistry*, *38*(4), 703–711. https://doi.org/10.1002/etc.4371

Siddiqui, S., Dickens, J. M., Cunningham, B. E., Hutton, S. J., Pedersen, E. I., Harper, B., Harper, S., & Brander, S. M. (2022). Internalization, reduced growth, and behavioral effects following exposure to micro and nano tire particles in two estuarine indicator species. *Chemosphere*, *296*, 133934. https://doi.org/10.1016/j.chemosphere.2022.133934

Siddiqui, S., Hutton, S. J., Dickens, J. M., Pedersen, E. I., Harper, S. L., & Brander, S. M. (n.d.). Natural and synthetic microfibers alter growth and behavior in early life stages of estuarine organisms. *Frontiers in Marine Science*, *9–2022*, in revision. https://doi.org/10.3389/fmars.2022.991650

Sol, D., Menéndez-Manjón, A., Carrasco, S., Crisóstomo-Miranda, J., Laca, A., Laca, A., & Díaz, M. (2023). Contribution of household dishwashing to microplastic pollution. *Environmental Science and Pollution Research*, *30*(15), 45140–45150.

Szule, J. A., Curtis, L. R., Sharpton, T. J., Löhr, C. V., Brander, S. M., Harper, S. L., Pennington, J. M., Hutton, S. J., Sieler, M. J., & Kasschau, K. D. (2022). Early enteric and hepatic responses to ingestion of polystyrene nanospheres from water in C57BL/6 mice. *Frontiers in Water*, *4*. https://www.frontiersin.org/articles/10.3389/frwa.2022.925781

Thornton Hampton, L. M., Bouwmeester, H., Brander, S. M., Coffin, S., Cole, M., Hermabessiere, L., Mehinto, A. C., Miller, E., Rochman, C. M., & Weisberg, S. B. (2022). Research recommendations to better understand the potential health impacts of microplastics to humans and aquatic ecosystems. *Microplastics and Nanoplastics*, *2*(1), 1–13.

Trasande, L., Krithivasan, R., Park, K., Obsekov, V., & Belliveau, M. (2024). Chemicals used in plastic materials: An estimate of the attributable disease burden and costs in the United States. *Journal of the Endocrine Society*, *8*(2), bvad163.

Tunnell, J. W., Dunning, K. H., Scheef, L. P., & Swanson, K. M. (2020). Measuring plastic pellet (nurdle) abundance on shorelines throughout the Gulf of Mexico using citizen scientists: Establishing a platform for policy-relevant research. *Marine Pollution Bulletin*, *151*, 110794. https://doi.org/10.1016/j.marpolbul.2019.110794

Werbowski, L. M., Gilbreath, A. N., Munno, K., Zhu, X., Grbic, J., Wu, T., Sutton, R., Sedlak, M. D., Deshpande, A. D., & Rochman, C. M. (2021). Urban Stormwater Runoff: A Major Pathway for Anthropogenic Particles, Black Rubbery Fragments, and Other Types of Microplastics to Urban Receiving Waters. *ACS ES&T Water*, *1*(6), 1420–1428. https://doi.org/10.1021/acsestwater.1c00017

Wieland, S., Balmes, A., Bender, J., Kitzinger, J., Meyer, F., Ramsperger, A. F., Roeder, F., Tengelmann, C., Wimmer, B. H., & Laforsch, C. (2022). From properties to toxicity: Comparing microplastics to other airborne microparticles. *Journal of Hazardous Materials*, *428*, 128151.

Wright, S. L., & Kelly, F. J. (2017). Plastic and Human Health: A Micro Issue? *Environmental Science & Technology*, *51*(12), 6634–6647. https://doi.org/10.1021/acs.est.7b00423