International Council of Chemical Associations

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# 2023 ICCA MARII WORKSHOP

Alexis Royal Sonesta Hotel

**Seattle, USA**

#microplastics

## ABSTRACTS and SPEAKERS BIOs

**Monday 12 June**

### Elevator pitches MARII Projects

**UTOPIA: Development of a mUltimedia uniT world OPen-source model for mIcroplAstic - ECO56**
*by Matt MacLeod, Stockholm University (presented by Blanca Serrano)*

The main objective of the ongoing UTOPIA project is to develop an open-source unit world multimedia modeling platform to synthesize knowledge and understanding about the fate of microplastic in the environment. The UTOPIA platform aims to provide an initial reference set of equations describing all known relevant fate process for microplastic on a software platform that will support screening level risk assessment and calculation of exposure indicators. UTOPIA will provide users with a database of generic plastic properties for archetypical plastics that can be used for comparisons with user-specified plastic types, and will support sensitivity and uncertainty analysis. The software will be open-source and modular in design to allow for ongoing model development as scientific understanding evolves. This presentation will describe the current state of UTOPIA model development, including the basic model structure and process descriptions that are included, and a summary of inter-relationships between UTOPIA and other CEFIC-funded projects (ECO57, ECO58, ECO59 and ECO60).

***Matthew MacLeod** is Professor of Processes & Dynamics of Environmental Pollutants at Stockholm University.*
*He is an environmental chemist and modeler studying factors that control human and environmental exposure to pollutants. It is in society's best interest to avoid pollutants that have high human and environmental exposure potential, especially if they lead to pollution that will be poorly reversible.*
*In his research group, researchers use conceptual and mathematical models to quantify exposure, and they design and interpret laboratory experiments and field studies in environmental chemistry that inform exposure assessments and modeling. The overall goals of their research are 1) to build a quantitative and process-level understanding of factors that determine exposure to environmental pollutants, and 2) to develop practical tools and guidance that supports rational management strategies for high exposure-potential pollutants.*

**ECO57 – µBETR Global – A global scale high-resolution multimedia environmental fate & transport model for micro- and nanoplastics**
*by Antonia Praetorius – University of Amsterdam (online)*

Understanding the transport dynamics of micro- and nanoplastics at the global scale, as well as their transformation pathways from source to sink, is crucial to inform regulatory efforts to reduce plastic pollution, design effective mitigation strategies and identify safer plastic alternatives. Here we introduce a recently developed global-scale fate and transport model for micro- and nanoplastics. Our µBETR Global model is a mechanistic multimedia mass-balance model developed to evaluate short- and long-range transport of micro- and nanoplastics and their transformation processes (e.g., weathering, fragmentation, additive release, biofouling, and aggregation). µBETR Global implements the latest developments in micro- and nanoparticle mobility and fate on a global scale with a 3D high resolution of 0.5° grid cells (equivalent to 55.0 km). Environmental system parameters are obtained from the Copernicus observation program, the European Centre for Medium-Range Weather Forecasts' (ECMWF's), and Era5 reanalysis data. The focus of this presentation will be a demonstration of atmospheric transport within µBETR Global and an illustration of the impact of the interplay between physicochemical properties of the micro- and nanoplastics and the weather conditions on their atmospheric residence time.

*__Dr. Antonia Praetorius__ is an assistant professor in environmental chemistry at the Institute of Biodiversity and Ecosystem Dynamics (IBED) of the University of Amsterdam (The Netherlands). Her research centers around assessing the fate, transport and impact of emerging anthropogenic contaminants in the environment. She has a strong expertise in particulate contaminants, such as engineered nanomaterials, nano- and microplastics and synthetic microfibers; additionally she researches (persistent) organic contaminants, such as PFAS and (psycho)pharmaceuticals, as well as emerging contaminants in circular systems (e.g. link to wastewater reuse). Her groups employs computational and analytical tools to increase our understanding of how the intrinsic physical and chemical properties of contaminants drive their behavior in different systems. Additionally, Antonia is engaged in citizen science to decrease the gap between academic research and society.*

**Emission factors for micro and nanoplastics – ECO60**
*by Sam Harrison, UKCEH*

Arguably the most important process affecting levels of plastics in the environment is their initial emissions, and this is therefore a key input parameter required by all fate and exposure models. In this presentation, I outline a new project EMIFACT-MNP (EMIssion FACTors for Micro and NanoPlastics), in which we are developing a model that predicts environmental emissions factors for the full size range of plastic emissions (macro, micro and nano), spanning the full range of professional, consumer and industrial scenarios and covering their whole lifecycle. We will parameterise the model for the 12 most-used polymers in Europe, plus rubber used in tyres. The model will provide emissions factors on a European scale, considering regional differences in lifecycle processes to produce country-specific emissions factors. Our project will deliver these emissions factors in SPERC-like documentation to support use in regulatory risk assessment, and all model code and associated guidance will be released open source for use by the wider community.

*__Sam Harrison__ is an environmental modeller at the UK Centre for Ecology & Hydrology in Lancaster, with a background in quantum physics and software development. His main specialism is the development of geospatial fate and exposure models for potential pollutants in soils and surface waters, including plastics, nanomaterials and organic micropollutants. He leads two Cefic-LRI funded projects on plastic fragmentation (ECO59) and emission factors (ECO60).*

**HERA-MP - Establishment of a holistic environmental risk assessment for microplastics in the terrestrial environment using the study of environmentally relevant particles - ECO61**
*by Karsten Schlich, Fraunhofer IME*

Recently a number of publications have drawn attention to various concerns related to the reliability and relevance of data published in the peer-reviewed literature with respect to the quality of ecotoxicological effects data for microplastic particles (MPs) (de Ruitjer et al., 2020 and Mehinto et al., 2022). An important observation from these studies regards the poor reporting of particle properties. In addition, most studies were limited to the testing of polystyrene (PS) spheres, which are not representative of an environmentally relevant type of particle and which are typically tested at concentrations well above those reported in the environment. Given that the observation of MPs in the environment is characterized by a complex heterogeneous mixture of particles, data that report adverse effects for a homogenous group of particles are insufficient to enable an assessment of risk, although they may be useful towards developing an improved mechanistic understanding between a specific suite of particle properties and a toxicological mode of action. Consequently, there is a need for future research to evaluate the adverse effects of environmentally relevant MPs.
It is also notable that the majority of ecotoxicological data available in the peer-reviewed literature relates to various aquatic test species with only a limited number of studies publishing original data on effects for terrestrial species. The paucity of effects data for terrestrial species represents an important limitation towards enabling the development and application of risk assessment for the terrestrial environment (Du et al., 2021; Hurley and Nizetto, 2018).
The aim of HERA-MP to develop a holistic environmental risk assessment for microplastics in the terrestrial environment. To achieve the aim a number of OECD/ISO standardized test systems will be applied to determine the chronic effect of several different types of MPs, including environmentally relevant MP as

well as on a subset of different types of MPs of specific composition, size and shape, on terrestrial organisms as microorganisms, plants and earthworms.
The purpose of testing an environmentally relevant MP is to evaluate the potential effects associated with a heterogeneous mixture of particles that have a specific relevance within the context of agricultural practices, observations from which can then be used to develop a holistic risk assessment framework.
The aim of testing a select number of homogenously distributed MPs is to evaluate potential toxicological mechanisms of action in relation to potential properties (e.g. size, shape and polymeric composition), which will be informed from observations obtained through a critical review of the literature within a SWOT analysis.

***Dr. Karsten Schlich** is an ecotoxicologist (PhD University Berlin 2013) working on the effects of chemicals (e.g. UVCB, nanomaterials, plant protection products) on aquatic and terrestrial organism for more than 15 years. Since 2019 he is head of the laboratory for aquatic primary producers and microbial diversity at the Fraunhofer IME. In his group ecotoxicological studies (under good laboratory practice) following standardized guidelines (OECD, ISO, OPPTS) are conducted, required for registration of the substances in the different chemical regulations. Another focus is the adaptation of risk assessment procedures and the conception and implementation of (higher tier) ecotoxicological studies for particulate materials (nanomaterials, micro- and nanoplastic particles).*

**Characterizing composition profiles and environmental risk of microplastics in Tokyo Bay, Japan**
*by Wataru Naito, AIST*

In recent years, there has been growing concern about the impact of microplastics (MPs) on marine ecosystems. This concern has led to increased political and social attention, both nationally and internationally. There has been a steady increase in the number of studies focusing on MPs in the marine environment, covering areas such as environmental monitoring, understanding their behaviour in the environment, developing analytical methods and studying their ecological effects. However, there is a lack of quantitative assessments of MPs that can contribute to the development of realistic strategies for risk-based management. To address this gap, we have conducted a comprehensive review of national and international literature related to the environmental risk assessment of MPs. In addition, we aimed to quantify the emission of MPs and assess their environmental risk specifically in Tokyo Bay. In this presentation, the progress made in the environmental risk assessment of MPs in Tokyo Bay will be presented, with particular emphasis on the development of SSDs and the characterization and correction of MP concentrations using newly acquired monitoring data.

***Dr. Wataru Naito** is currently a group leader of Research Institute of Science for Safety and Sustainability (RISS) at National Institute of Advanced Industrial Science and Technology (AIST), Japan. At AIST-RISS, research of his group focuses broadly on risk assessment and management of various kind of hazards (chemicals, nanomaterials, radiation and microbiological). Currently, his research activities include developing methods for obtaining missing data for risk assessment of chemicals and promoting pragmatic risk assessment for solving social issues such as radiation exposure owing to the 2011 Fukushima accident, microplastics and SARS-Cov-2 viruses. He has served on a variety of expert advisory committees related environmental risk-related issues for central and local governments and been a member the Working Party on Exposure Assessment (WPEA) in OECD since the noughties. Dr. Naito received a BS in Environmental Science from Virginia Polytechnic Institute and State University (Virginia Tech), a MA and PhD in Materials Science and Chemical Engineering from Yokohama National University.*

**Characterization of exposures to airborne human-respirable microplastic particles**
*by Alison Elder, University of Rochester*

Plastics and their breakdown products are ubiquitously present in the environment from a variety of sources. Analysis of air samples has revealed the presence of fragmented, spherical, and fibrous plastic particles in a wide range of sizes from the submicrometer scale up to tens of micrometers in length and diameter. While large micrometer-millimeter sized particles may have relevance for some routes of entry into the human body, inhalation exposure via the respiratory tract is strongly limited by airborne particle size. However, few studies have addressed the possible health consequences associated with exposures to airborne plastics and, more specifically, whether the smaller particles, namely microplastics, can enter the respiratory tract at all. Whether microplastics have unique toxicological properties in comparison to other particle types is also unknown. Our work has sought to address critical questions about the inhalability and respirability of microplastics in indoor and outdoor air via particle size-restricted sampling coupled with morphological assessment and estimation of plastic burdens via Nile red staining. We found Nile red-positive (putative plastic) particles in air samples from indoor environments (office, campus/household laundry rooms, 3-D printing/engineering laboratory), most of which appeared to have a fragment-like morphology. These particles represented ~1% of the total collected sample in terms of number. Importantly, these particles were also found when sampling was restricted to the human-respirable fraction (<4 μm in aerodynamic diameter), suggesting that they can reach the gas exchange region. Ongoing work is focused on identifying the polymeric species in these air samples, their distribution across particle size classes, and whether indoor and outdoor microplastic particles are similar in terms of morphology, size, and chemistry.

***Alison Elder** is an Associate Professor of Toxicology in the Department of Environmental Medicine at the University of Rochester School of Medicine and Dentistry. As an inhalation toxicologist, Dr. Elder's research interests include the pulmonary, cardiovascular, and central nervous system inflammatory and oxidative stress-related effects of air pollution – specifically, airborne particles – engineered nanomaterials, and microplastics. She co-directs both the Environmental Health Sciences Center's Inhalation Exposure Facility and the Toxicology Training Program at the University of Rochester. Dr. Elder has authored numerous research papers in the field, as well as review articles and book chapters, and serves on several editorial boards. She has also served for over 10 years on the Threshold Limit Value-Chemical Substances committee of the American Conference of Governmental Industrial Hygienists.*

**Development of MNP Health & Environmental Literature Platform (MNP-HELP): A curated Literature Repository for Risk Assessment Research**

*by Julie Panko, ToxStrategies*

A single, centralized, and systematically curated literature repository of research informing the health and environment risk assessment of micro/nanoparticles (MNP) eliminates the need for researchers and manufacturers to independently track and review scientific literature and can serve as a starting point to streamline literature reviews and data gathering for existing and future R&D projects. This presentation will describe the progress in literature curation and the development of a searchable, user-friendly database of literature and associated meta-data of relevant research.

***Julie Panko** is a Principal Scientist and Practice Director of the Exposure Sciences group at ToxStrategies. She has more than 30 years of experience conducting and managing a wide variety of occupational, environmental, and consumer health risk assessments and is a Certified Industrial Hygienist (CIH). She has focused primarily on evaluating chemical risks from industrial, commercial, and consumer products within the context of various regulatory programs and voluntary initiatives. Ms. Panko has lead teams investigating the fate and transport of microplastics from land releases and is an international expert on potential human and ecological health risks associated with tire and road-wear particles. Ms. Panko is currently leading the project to develop the MNP Health and Environmental Literature Platform on behalf of the Foundation for Chemistry Research & Initiatives.*

**Brigid Project**

*by Camilla Carteny, PlasticsEurope*

Brigid, funded by Plastics Europe, is a scientific research project aimed at evaluating the potential risks posed to human health by microplastic (MP) exposure through ingestion. Over a span of five years, the project focuses on secondary MPs derived from seven different polymer types. The project encompasses five main objectives, organized into six working packages (WPs). These objectives include the creation and characterization of secondary MPs in relevant size ranges, as well as the development of innovative labelling techniques to facilitate exposure studies. Additionally, the project aims to quantify human internal exposure to MPs through in vitro biokinetic and in vivo studies. This data, combined with information from existing scientific literature, will contribute to the development of a highly detailed in silico exposure model. Moreover, Brigid adopts a tiered approach for its hazard assessment. Starting with basic in vitro human cell models and progressing to advanced ex vivo models, the project ultimately derives benchmark results from in vivo animal models. These findings will inform the development of a hybrid Risk Assessment framework that blends solid in vivo-based assessments with elements of next-generation in vitro approaches. Currently underway, Brigid has made progress in two areas: the production of microplastic testing materials from member polymer grades in WP1 and the Human Stool Study in WP2, with results expected during the summer. The project holds great promise in enhancing our

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| understanding of the potential health risks associated with microplastic exposure and informing evidence-based recommendations for risk management. | |
| | ***Camilla C. Carteny*** *is Technical Project Manager at Plastics Europe, the pan-European trade association of plastics manufacturers. Her main topic of expertise within the association is nano- and microplastics, both in a human health and environmental context. She joined Plastics Europe in 2021, having previously worked in academia on a number of international publicly funded scientific research projects related to microplastics.*<br>*Camilla is a Marine Biologist with a background in Aquatic Toxicology. She performed her PhD research at the University of Antwerp, within a project dedicated to microplastics and conventional and biodegradable polymers' behaviour in the marine environment.* |

## Reference Materials - Status and Needs

**The need for reference materials in microplastics studies from a toxicological perspective** (online)
*by Ingeborg Kooter, TNO*

***Ingeborg Kooter*** *PhD ERT (F) is working at TNO, department of circular economy and environment as a senior scientist. She has a background in molecular sciences, obtained a PhD (1999) in biochemistry at University of Amsterdam and is a European registered toxicologist. She has worked at Unilever Research Vlaardingen and the National Institute of Health and Environment (RIVM) in the Netherlands before she joined TNO in 2007. Since 2020 she has a part-time position at Maastricht University, in the Pharmacology and Toxicology department. She has been leading and participating in national and (inter)national research projects in the field of health effects of environmental pollutants. She is particularly interested in the health effects of environmental issues such as air pollution, nanoparticles and microplastics. Working in the field of exposure and hazard assessment, she has a keen interest in developing a way to judge whether the air we breathe is healthy.*

**Reference materials: Literature review**
*by Todd Gouin, TG Environment*

Micro- and nanoplastic particle (MNP) research is at a nascent stage, with numerous studies observing a need to adopt robust quality assurance / quality control (QA/QC) practices regarding sample collection, analysis and effects testing. Good QA/QC is needed to support the reliability and relevance of data generated, which further supports comparability across studies and which further strengthens the ability to perform a risk assessment. It is generally understood that an important element of QA/QC protocol relates to a demonstrated understanding of the characteristics of the stressor under investigation. The development and application of sampling and analytical methods, for instance, relies on the use of analytical standards, which are used to quantify the efficacy of the sampling and analytical method, such as in the reporting of recovery efficiencies or in the use of quantifying calibration curves. At present, there are no readily available standardized MNP reference materials or methods. Consequently, it is difficult to ascertain the environmental and human health risks from existing studies because the exposure data may be of varying quality and reproducibility. The lack of availability to standard reference materials represents an important barrier towards strengthening the quality of MNP research, and are thus urgently needed. Access to standard materials and/or methods aimed at generating MNPs would serve a variety of needs, but would be particularly valuable in supporting the adopting of good QA/QC practices for both environmental monitoring and effects testing, thus helping to strengthen the quality and reliability of data to support risk-based decisions. This presentation reports results from a literature review aimed at summarizing the approaches that various groups have adopted towards generating MNPs in the laboratory.

***Dr. Todd Gouin*** *received a PhD specializing in the field of environmental chemistry from Trent University, in Canada, through the Watersheds Ecosystems Graduate Programme in June 2006. Following his graduate studies, Dr. Gouin, has obtained both experimental and modelling experience in assessing diverse chemical exposures including current use pesticides in Costa Rica and polycyclic aromatic hydrocarbons in the Arctic regions of Alaska. More recently, he was employed for eight years by Unilever, where he was involved in the development and application of tools aimed at both screening and prioritization of chemicals and higher-tier risk assessment methods. He now provides consultancy work on a range of topics, where his current research interests include the development and application of risk assessment methods, such as for microplastic particles.*

**Reliably generating microplastic particles for laboratory testing** (online)
*by Christie Sayes, Baylor University*

There is a need to generate microplastic particles in a desired size range to perform systematic environmental health and safety studies reproducible across different laboratories worldwide. However, the scientific community has found it difficult to produce reliable microplastic particle size populations that is scalable, free of contamination, narrow size distribution, and composed of different polymer types. This research aims to produce a documented methodology that generates microplastic particles < 10 mm in diameter and in sufficient quantities necessary to create a microplastic reference material library. Polymer types relevant to this work include low-density and high-density polyethylene. Each of the microplastic particle populations produced by each experiment was characterized for size and size distribution. The experiments used in this study include mechanical grinding, chemical precipitation, microorganism breakdown, and enzymatic degradation. We expect this work to aid in the micro- and nano-plastic particle research community's efforts to understand plastic pollution's environmental impacts.

***Dr. Christie M. Sayes*** *is a practicing research scientist, consultant, and academician in toxicology, chemistry, material science, and environmental health. Currently, she holds the Associate Professor of Environmental Science & Toxicology position at Baylor University (Waco, Texas). Sayes is a subject matter expert in the chemistry of materials, exposure science, health effects, and risk. Her activities include working with partners, collaborators, and trainees in designing studies related to safety-by-design considerations of engineered substances and emerging contaminants used in pharmaceutical, agricultural, and consumer products. Sayes is also interested in occupational safety and environmental transformations of chemical and particle systems in complex matrices. She possesses a working knowledge of laboratory science and U.S. regulatory climates. Routine activities include validating zebrafish, mouse, and rat in vivo models and alternatives to animal models, biological and chemical molecular mechanistic analyses, toxicological mechanisms, mass spectrometry, electron microscopy, and statistics. Data sets are always related to the published literature, compared against appropriate controls, and verified using orthogonal methods.*

**Progress with reference materials in Europe**

*by Wendel Wohlleben, BASF and Luke Parker, TNO*

With the plethora of studies on microplastics a need for microplastic references is needed yet unfulfilled. Not only is there a lack of references there is also a lack of diversity in polymer type for references, especially in toxicological studies. In specific, inhalation studies must rely on microplastics that are respirable and/or inhalable (< 10 µm) to enable the testing of toxicological outcomes. The present contribution has gathered input from various publicly funded projects on the EU side (BAM, JRC, CUSP), and adds in detail the status of reference materials in the two industry-funded toxicology projects in Europe, namely BRIGID (presented by Luke Parker, TNO) and C10 (presented by Wendel Wohlleben, BASF). The different production routes cover both mechanical micronisation and solvent precipitation and covers various polymers. Specific attention is given to the characterization, storage, and dispersability in cell culture conditions. We will also emphasize the need to demonstrate that the produced microplastic references are representative for the intended exposure scenario, by characterization of its original material molecular and particle descriptors: Chemical composition, molecular weight, crystallinity, solidity, density, are among the descriptors tested for both the produced microplastic references and its corresponding commercial counterpart.

***Dr. Wendel Wohlleben*** *is Senior Principal Scientist at BASF, Dept. of Material Physics with a second affiliation to the Dept. of Experimental Toxicology and Ecology. He studied physics (minor chemistry) at the University Heidelberg and at the Ecole Normale Supérieure in Paris. He obtained his PhD from the University of Munich with a biophysical thesis on energy harvesting in photosynthesis, performed at the Max-Planck-Institute for Quantum Optics. The post-doc at Physical Chemistry, University Marburg was devoted to chemically resolved microscopy. Dr. Wohlleben is a researcher at BASF since 2005, interrupted by a sabbatical leave to the Weizmann Institute, Rehovot, and was visiting scientist at Harvard TH Chan School of Public Health, Boston (2012 to 2019).*

*At BASF, Dr. Wohlleben leads the research cluster on the impact assessment of nanomaterials, and another cluster on microplastics. His own labs develop and apply methods to characterize the interaction between such colloids and their environment, e.g. for grouping purposes. New aspects consider lifecycle releases from advanced materials that combine several components to achieve an intended functionality. At BASF, Dr. Wohlleben leads the research cluster on the impact assessment of nanomaterials, and another cluster on microplastics. His own labs develop and apply methods to characterize the interaction between such colloids and their environment, e.g. for grouping purposes. New aspects consider lifecycle releases from advanced materials that combine several components to achieve an intended functionality.*

***Dr Luke Parker*** *is a Scientist at TNO, the Dutch Institute for Applied Natural Sciences. He did his PhD at Cardiff University in the group of Prof. Graham Hutchings investigating the design of novel nanoalloy catalysts for hydrogen production through ammonia decomposition. Afterwards he moved to Utrecht University and the group of Prof. Bert Weckhuysen where he worked as a postdoc focussing on catalyst characterisation using micro-spectroscopic methods with a special focus on confocal fluorescence microscopy and single molecule fluorescence. In August 2021, he moved to TNO where he currently investigates how we can better detect and characterise microplastics, where they come from, and how we can minimise their formation.*

## Microplastic effects testing with relevance for environmental modelling and risk assessment

### Unveiling the effects of microplastics: QA/QC, effect thresholds and effect mechanisms

*by Vera de Ruijter, WUR*

There is a recognized need for improved methods in plastic research due to current limitations in quality assurance and harmonization, hindering our understanding of the true effects of microplastics in the environment. In this study, 105 microplastic effect studies with aquatic biota were reviewed, and a method to assess the quality of such studies was proposed. Here we developed 20 quality criteria in four main categories: particle characterization, experimental design, applicability in risk assessment, and ecological relevance. The average score for the studies was 44.6% of the maximum score, indicating a significant need for better quality assurance. Urgent recommendations for improvement included avoiding and verifying background contamination and enhancing the environmental relevance of exposure conditions. While most studies properly evaluated particle characteristics, there was a mismatch between the sizes tested and those targeted in environmental samples. Additionally, many studies proposed mechanisms that lacked sufficient support from the study design and data reporting, which poses a problem for decision-makers and necessitates improvement in future research. Three effect mechanisms, namely inhibition of food assimilation and/or decreased nutritional value of food, internal physical damage, and external physical damage, remained when accounting for study quality. These mechanisms should be given higher priority in risk assessment.

***Vera de Ruijter** is a PhD student at Wageningen University, specializing in the field of ecotoxicology with a particular focus on the effects of microplastics on marine and freshwater organisms, as well as risk assessments associated with plastic pollution in the environment.*

### A recipe for environmentally realistic microplastic to use in effect tests

*by Bart Koelmans, WUR*

This abstract proposes a recipe for preparing environmentally realistic microplastic particles for use in effect tests. Current effect tests are limited to using monodisperse, limited disperse, or single-type particles, which are less diverse than those found in nature. This limits the relevance of the tests, and it is more logical to use particles that are similar to those in nature. While it is impossible to create a perfectly heterogeneous mixture of particles like those found in nature, it is sufficient to maintain realism in terms of heterogeneity that is toxicologically relevant, and relevant to the specific question of risk assessment for which the test data are intended. We provide practical guidance on designing and preparing these microplastics, which can also be used to test non-polymer particles. This approach allows for comparisons of the intrinsic toxicities of different environmentally realistic particle or material types.

***Dr. Bart Koelmans** is an environmental chemist and ecotoxicologist by training and heads the Department of Aquatic Ecology and Water Quality at Wageningen University. In the field of plastics research, his group combines conceptual modelling and empirical approaches to gain a mechanistic understanding of the risks posed by microplastics to human health and the environment. Bart is a global highly cited researcher (Clarivate Analytics), advises international organizations like the World Health Organization, led international working groups about risks of plastic pollution, such as the European Commission's Science Advice for Policy by European Academies (SAPEA) expert group on Microplastics in Nature and Society, and is Editor-in-Chief of the new journal Microplastics and Nanoplastics. For more information, see www.microplasticlab.com.*

### Current research initiatives and strategies for microplastic management in California

*by Leah Thornton Hampton, SCCWRP*

Microplastic research has been ongoing for decades, but, in recent years, legislative mandates to develop environmental management strategies for microplastics have spurred a flurry of activity to standardize methodologies and develop health-based thresholds to initiate monitoring programs both for drinking water and the environment, particularly coastal habitats. The State of California has emerged as a leader in addressing microplastic pollution, initiating efforts to standardize both sample collection and analysis methods for microplastics, develop health-based thresholds for drinking water and coastal habitats, and lay the foundation for microplastic monitoring across the state. The Southern California Coastal Water

Research Project is currently coordinating and supporting multiple initiatives to address microplastic contamination. Specifically, efforts to evaluate collection methods in ambient water, sediment, biota, and stormwater were recently initiated with stormwater identified as the highest priority given that stormwater is predicted to be a major pathway for microplastics entering coastal habitats and the high level of uncertainty in existing collection methods. Method evaluations for sample processing and analysis are either in their late stages or complete. So far, a standardized method and laboratory accreditation program for analyzing microplastics in drinking water are available. Standardized methods for measuring microplastics in complex matrices such as sediments are anticipated to follow in the coming months. Preliminary health-based thresholds and a preliminary-screening level have been derived for ambient water and drinking water, respectively. Through these activities and others, critical research needs were also identified, laying the groundwork for the next phase of microplastic research and environmental management in California.

***Dr. Leah Thornton Hampton*** *is a Scientist in the Toxicology Department at the Southern California Coastal Water Research Project (SCCWRP) in Costa Mesa, California where she specializes in characterizing the toxicological effects of environmental contaminants and is currently focused on studying microplastics. Much of her recent work has been focused on standardizing collection and analytical methods for microplastics as well as conducting primary research to better understand microplastic hazards and develop health-based thresholds. Her technical expertise includes endocrine disruption, reproductive toxicity, developmental toxicity, and immunotoxicity. Prior to joining SCCWRP, her research focused on the effects of early life stage thyroid suppression on immune function. She holds a Ph.D. in biology from the University of North Texas, an M.S. in biology from Texas Christian University and a B.S. in zoology from Miami (Ohio) University.*

**Higher-tier community effects of nano- and microplastics in the context of risk assessment**
*by Paula Redondo Hasselerharm, IMDEA Water*

Due to the ubiquity of microplastics, their impacts have been assessed for a wide range of aquatic and terrestrial species over the past decade. In the literature, most of the studies evaluating the effects of nano- and microplastics focus on single species using controlled laboratory conditions. Although obtaining individual effect thresholds is very useful to assess the environmental risks of nano- and microplastics at lower tiers, data on the long-term implications of nano- and microplastics at the community level tested under ecologically realistic conditions are scarce. The characterization of the risks of nano- and microplastics at higher tiers is extremely relevant, as the detection of negative effects within higher levels of biological organization could trigger responses that can affect the whole community, and because the effects found are closer to what will happen in nature. In this presentation, we will provide a literature overview on the long-term experiments conducted to date at population and community levels with nano- and microplastics mimicking freshwater, marine and soil ecosystems using mesocosm and field scale experiments. We will also present the methodology used and the results obtained in a 15-month outdoor experiment where a freshwater community was exposed to nano- and microplastics using mesocosms. Lastly, we will provide guidance on how these community effect thresholds could be used in risk assessment.

***Dr. Paula E. Redondo Hasselerharm*** *is a biologist with a MSc degree in Water Quality and a PhD degree in Environmental Sciences, which she obtained at Wageningen University & Research (The Netherlands). The main objective of her thesis was to study the effects of nano- and microplastics on aquatic ecosystems by carrying out single species tests in the laboratory, as well as outdoor mesocosm experiments. Her research training has been completed by working at the University of Amsterdam and KWR Water Research Institute, in The Netherlands, and in the Barcelona Institute for Global Health and Granada's Water Institute, in Spain. She is author of 23 scientific articles Q1 in the JCR index and has participated in various international conferences. Since July 2021, Paula is a postdoctoral researcher at the Ecotoxicology group of IMDEA Water (Spain) and currently works in the H2020 Papillons project, whose purpose is to study the impacts of microplastics on agricultural systems. Her main tasks in this project are to conduct field scale experiments to assess the effects of polyethylene and biodegradable films on crop production, soil invertebrates, soil microorganisms and soil properties.*

**Microplastic particle effects and risks: The way forward**
*by Todd Gouin, TG Environment*

There continues to be a substantial growth in microplastic research, with many groups aimed at evaluating their effects in various species and across different endpoints aimed at helping to inform an evaluation of risk. A key challenge, however, remains on how to interpret the environmental relevance of results. For example, is it possible to differentiate and identify which properties of the microplastic particles represent an intrinsic hazard with respect to a specific hazard endpoint, such as size, shape and/or polymer composition. Examples of adverse effects reported, however, suggest that exposure at elevated concentrations can result in a variety of responses, with inflammation, oxidative stress and/or effects on behaviour, growth and reproduction being reported, implying that responses are potentially influenced by a system-dependent property as defined by concentration. Recent research, as presented as part of this session summarizing results from a select number of recent activities propose innovative strategies that may help to address some of the challenges identified towards helping to move things forward. This presentation aims to reflect on recent advances – is the research addressing all the issues, are things moving forward or are there still areas that need to be addressed.

***Dr. Todd Gouin*** *received a PhD specializing in the field of environmental chemistry from Trent University, in Canada, through the Watersheds Ecosystems Graduate Programme in June 2006. Following his graduate studies, Dr. Gouin, has obtained both experimental and modelling experience in assessing diverse chemical exposures including current use pesticides in Costa Rica and polycyclic aromatic hydrocarbons in the Arctic regions of Alaska. More recently, he was employed for eight years by Unilever, where he was involved in the development and application of tools aimed at both screening and prioritization of chemicals and higher-tier risk assessment methods. He now provides consultancy work on a range of topics, where his current research interests include the development and application of risk assessment methods, such as for microplastic particles.*

**Tuesday 13 June**

## Degradation Processes of Microplastics

**Generation of microplastics in the ocean environment**
*by Anthony Andrady, North Carolina State University*

Most floating plastics in the ocean are polyolefins, polyethylene, and polypropylene, known to undergo photo-initiated degradation in air. While their mechanism of degradation that ultimately leads to fragmentation into microplastics is relatively well understood, the corresponding process for these plastics occurring in seawater environments remains largely unexplored. Our research aims to compare the degradation and fragmentation processes in air and seawater, highlighting less understood aspects of the process. Findings from accelerated weathering of polyethylenes in air and seawater suggest diffusion-controlled oxidation of the polymer results in localized degradation in a thin surface layer. Therefore, their photooxidative fragmentation into micro- and nanoplastics results in very small microplastics and readily apparent macro fragments or mesoplastics.
Furthermore, if the duration of solar exposure of floating plastics in the ocean is adequate to obtain fragmentation remains debatable. If such fragments are indeed formed in air or in seawater exposures of plastics, their lifetime in the environment is likely to be short. This is because of photo mineralization, a concurrent process that removes polymer fragments from the environment. Initial exposure studies show this to be the case for polyethylenes, including photodegradable polyethylenes used in packaging applications.

***Anthony (Tony) Andrady** is among the first researchers to study the degradation of plastics in the marine environment and has authored over 150 research papers and authored or edited five books with John Wiley on polymer-related subjects. As a senior researcher at the Research Triangle Institute, he directed research programs for the USEPA, the Department of Defense, the Department of Commerce, and the National Oceanic and Atmospheric Administration. He served as a member of the GESAMP WG4 panel on plastics pollution of the ocean and presently serves as the chair for Materials Degradation and the microplastics groups on the panel on effects of UV radiation on materials, convened by the UNEP under the implementation of the Montreal Protocol.*

**Linking formulation to the fate and impacts of plastics in sunlit surface waters**
*by Bryan James, WHOI*

The dozens of polymers and thousands of organic and inorganic additives added to polymers make plastic pollution a "wicked" problem. Relative to organic additives, the potential control of consumer plastic fate, persistence, and toxicity by inorganic additive content is less understood. We focused our efforts on polyethylene (PE) grocery bags because they are commonly found in beach surveys and relevant to regulatory and consumer decision-making. Our group found PE grocery bags can be ~30 wt% inorganic additives, mainly calcium carbonate (a filler) and a few wt% titanium dioxide (a common white pigment and photocatalyst). Bags containing titanium dioxide had enhanced photochemical degradation potential compared to additive-free PE, indicating that inorganic additive formulation could control photochemical fate. Similarly, the extent of biofouling of PE, a potential pathway to slow photo-oxidation, was formulation dependent, with less light-shielding by biofilms growing on PE with titanium dioxide. As PE degrades by photochemical processes, leachable photoproducts are created. Using ultrahigh-resolution Fourier transform ion cyclotron mass spectrometry, we found that the water-soluble photoproducts from PE bags consist of tens of thousands of compounds and are chemically distinct, differentiating by the bag's formulation. Of concern is whether this complex mixture of plastic photoproducts poses any toxicological risk. Using a zebrafish developmental bioassay, we exposed developing larvae to PE bag photoproducts generated from "worst-case" plastic concentrations. Genome-wide gene expression analyses conducted after five days of exposure indicated potential neuromuscular toxicity. These sublethal effects were formulation specific and were muted for the photoproducts produced from bags containing titanium dioxide, suggesting that the persistence of consumer plastics and toxicological impacts of photoproducts could be attenuated by product formulation. Though promising, there is still much to do. Future directions aim to understand the role of plastic properties (formulation, geometry, molecular weight, optical properties) toward a predictive structure-property-environment understanding of photochemical fate, persistence, and toxicity.

*__Dr. Bryan D. James__ is a postdoctoral researcher at the Woods Hole Oceanographic Institution jointly appointed in the Departments of Marine Chemistry and Geochemistry, and Biology, working with scientists Collin P. Ward, Christopher M. Reddy, and Mark E. Hahn. Bryan received his Ph.D. in materials science and engineering from the University of Florida in May 2021, where he was a National Institutes of Health NRSA Predoctoral Fellow supported by the National Heart, Lung, and Blood Institute and his B.A.Sc. in materials engineering from the University of Toronto. Bryan's past research has focused on biofouling, precision regenerative medicine, cell-material interactions, and the biocompatibility of materials. His current work addresses the fate, persistence, and toxicity of plastic in the environment toward developing next-generation ecocompatible materials. In doing so, Bryan takes a convergent approach by integrating concepts from materials science, environmental science, and medicine. Bryan has received numerous awards and honors, including being named a 2022 Polymeric Materials Science and Engineering Future Faculty Scholar, a 2022 Distinguished Young Scholars Seminar speaker, and a 2023 CAS Future Leader.*

**Processes of environmental plastic weathering and biodegradation in natural systems (and how to study them)** (online)
by Melissa Duhaime, University of Michigan

PROBLEM: From both environmental health and resource sustainability perspectives, there is global interest in reducing the amount of plastic debris accumulation in Earth's waterways. To effectively target major sources and pathways on a global scale, the question remains: What is the physical fate of plastic once in natural waterways? Our work is experimentally resolving the knowledge gaps regarding the fate of plastic debris in natural systems.
APPROACH: In both in situ and laboratory settings, we have combined analytical chemistry with environmental microbiology to study UV- and biodegradation effects on polyolefin products designed for packaging. Following UV exposure, we observed increases in LLDPE and HDPE hydrophilicity, increase in unsaturated structures and polar groups (hydroxyl groups and carbonyl groups) with time (with degree of degradation inversely related to PE density), and increase in degree of HDPE crystallinity. The modulus of the HDPE sample shows an upward trend after weathering, indicating a greater degree of embrittlement as a result of photooxidation. Towards biodegradation, we have established a culture collection of 16 bacterial and fungal strains from a range of habitats (e.g., water, ocean, soil, wounds), generated genome sequences, and established the potential for a number of them to remineralize PE-C to carbon dioxide. We have used comparative genomics to identify shared metabolic pathways. These results inform the taxonomic and functional analysis of biofilms from plastics recovered from the environment, bridging the gap between characterized single strain isolates and largely uncharacterized mixed microbial communities. In field and lab studies, we have found microbial colonization of plastics is specific to polymer formulation, depth, and extent of UV pre-aging. We have observed fungi have much greater potential for PE remineralization than bacteria, and we have determined the rates of biofilm growth in the environment, which is essential to the hydrodynamics that underlie plastic transport models. OUTLOOK: These outputs are being used to develop new metabolic models of PE-degrading microbes and multi-species consortia that can be used to predict the impact on genetically-engineered organisms, identify growth factors needed by hard to isolate microbes, and predict outcomes for different polymer formulations and environmental conditions.

*__Melissa Duhaime__ is an Associate Professor of Ecology and Evolutionary Biology at the University of Michigan. Through her research and teaching, has applied her expertise in environmental microbiology and microbial ecology to address pressing issues in water sustainability, such as microplastics pollution, algal blooms, avian botulism, and oil pipeline risks. She is an engaged community scholar, having testified before the US Senate on microplastics pollution in the Great Lakes, trained as a Science Communication Fellow with the University of Michigan Museum of Natural History, and hosted and participated in numerous science outreach events, from improv comedy and science classroom programs in Detroit and southeast Michigan to Science Cafés and regular museum appearances in Ann Arbor.*

**Predicting plastic fragmentation in the environment**
*by Sam Harrison, UKCEH*

The breakup of plastic into increasingly smaller fragments is an important process, potentially affecting bio-uptake, transport and ultimately risk. Fragmentation is a complex process that depends not just on the type of polymer, but also the degradation stresses (e.g. UV light, hydrolysis, biodegradation) and

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| mechanical disruption encountered in the environment. In the FRAGMENT-MNP project (Micro and NanoPlastic FRAGMentation in the ENvironmenT), we are developing the first model of plastic fragmentation that considers all of these factors, enabling realistic predictions of the evolution of particle size distributions across a broad range of commonly used polymers and environmental compartments. The model is being parameterised by an extensive experimental database that we are building, which is elucidating the impact of these different factors on fragmentation rates. Ultimately, the model will be able to be integrated into fate and exposure models to give more accurate predictions of plastic exposure in the environment. In this presentation, I will give an update on progress in developing the model, preliminary results from the experimental work, and a roadmap for integrating experimental data. | |
| | ***Sam Harrison*** *is an environmental modeller at the UK Centre for Ecology & Hydrology in Lancaster, with a background in quantum physics and software development. His main specialism is the development of geospatial fate and exposure models for potential pollutants in soils and surface waters, including plastics, nanomaterials and organic micropollutants. He leads two Cefic-LRI funded projects on plastic fragmentation (ECO59) and emission factors (ECO60).* |

## IVIVE in human toxicology assessment of microplastics

**Some fundamentals of particle dosimetry for risk-directed studies**
*by Justin Teeguarden, PNNL*

The value of both exposure and toxicity directed experimental work is greatest when measures of exposures (doses) are both accurate and relevant for the purpose of understanding risks. Specifically, measures of exposure in test systems are most valuable when they can be used to translate findings directly to a particular target, a cell, an organism or population. The physical and chemical properties of particles, for example microplastics, produce pharmacokinetic behaviors in in vitro systems that are very different from chemicals, and present unique challenges to both measurement and translation of doses from these in vitro test systems and humans. The basic principles of particokinetics for liquid in vitro systems will be presented from the perspective of translating exposures and effects across test systems. Some examples and tools will also be presented to set the stage for workshop discussions that will follow.

*__Justin G. Teeguarden__ is the Chief Science Officer for the Environmental and Molecular Sciences Laboratory where he leads the S&T Strategy. He holds a joint faculty position with the Oregon State University (OSU) Department of Environmental and Molecular Toxicology, where he served as the director of the OSU–PNNL–Superfund Center Research Translation Core. He is a PNNL Laboratory Fellow. Dr. Teeguarden was the chief exposure scientist and led the exposure science team and Defense Health Programs at PNNL. He is Catalyst for PNNL's Innovation Foundry. Dr. Teeguarden has more than 20 years of experience in computational and experimental exposure assessment in humans, animals, and cell culture systems. His particular focus has been the utilization of emerging technologies, novel experimental data, and computational methods for addressing public health challenges related to human exposure to chemicals. His experience includes developing physiologically based pharmacokinetics models for volatile and non-volatile organics, trace metals and nanomaterials (particles). These models were developed as tools for understanding the relationship between external exposure and internal exposures for purposes of comparing human exposure to those in toxicity test systems (such as, rodents and cell culture systems).*

**Earlier and novel findings from inhalation studies of ultrafine particles: Predictors for effects and biokinetics of inhaled micro- and nano-plastics?**
*by Günter Oberdörster and Uschi Graham– University of Rochester*

*__Günter Oberdörster__ is Professor Emeritus in the Department of Environmental Medicine at the University of Rochester, has been the Director of an EPA funded University of Rochester Ultrafine Particle Center, PI of a DOD funded Multidisciplinary Research Initiative in Nanotoxicology and Head of the Pulmonary Core of the NIEHS Center Grant. His research includes the effects and underlying mechanisms of lung injury induced by inhaled non-fibrous and fibrous particles, including extrapolation modeling and risk assessment. His studies with ultrafine particles and engineered nanoparticles influenced the field of inhalation toxicology, raising awareness of the unique biokinetics and toxicological potential of nano-sized particles. He earned his D.V.M. (1964) and Ph.D. (Pharmacology, 1966) from the University of Giessen in Germany. He emphasizes specifically the use of realistic exposures and relevant doses to establish exposure-dose-response relationships in order to translate experimental results for assessing human risk through dosimetric extrapolation modeling. Results from his laboratory in the early 90's were the first to point out the potential of ambient ultrafine particles to cause adverse effects. He introduced the Ultrafine Particle Hypothesis. At the same time he pointed out the propensity of nano-sized particles to travel from deposition sites in the respiratory tract to secondary organs by translocating across epithelial barriers to the blood and lymph circulation and along sensory nerves to the CNS. He proposed the importance of particle dimensional and functional surface area properties as a most important dosemetric. His research continues to assess the correlation between physicochemical and functional properties and effects of inhaled nanoparticles on the pulmonary, vascular and central nervous systems. He has authored and co-authored over 340 (including book chapters) publications related to environmental and occupational health, dosimetry, extrapolation modeling and risk assessment. The fate of inhaled nano-sized particles involving their biopersistence and translocation from the portal-of-entry – the respiratory tract – to secondary organs – particularly the central nervous system - has become his major interest.*

**In-vitro inhalation microplastics assessments: IVIVE approaches**
*By Tanja Hansen, Fraunhofer ITEM*

Humans are ubiquitously exposed to diverse classes of microplastic (MP) materials and the inhalation route is probably the most important exposure route for airborne microplastic particles. Pulmonary cell cultures at the air-liquid interface (ALI) can be utilized to assess potential adverse effects of microplastic particles under realistic conditions. To enable toxicity ranking, we propose an approach based on comparison to reference compounds with existing in-vivo date (rat or human). Relating the results of in-vitro studies to the human in vivo situation needs careful consideration and there are different approaches to perform in-vitro to in-vivo extrapolation (IVIVE). Benchmark concentrations describing the onset of a toxicological response in the in-vitro system can be extrapolated to a corresponding external concentration by reverse dosimetry. Lung retention as well as uptake and subsequent systemic availability of MP particles can be estimated by physiologically based kinetic (PBK) modelling and appropriate in-vitro experiments with pulmonary barrier models are useful tools to parameterize such models. However, there are specific challenges when performing in-vitro experiments with MP materials, for instance the generation of test material in an appropriate size range or analytical challenges complicating the visualization and quantification of materials inside cells and biological matrices. This talk highlights exemplary results obtained during the Cefic C10 project with selected MP materials. First, as currently available reference materials are in a size range that is not respirable or even suitable for in vitro testing, appropriate methods for the generation of MP particles in a smaller size range were developed based on solvent precipitation and provided large volume fractions of small size particles with 95% of particles < 10 µm. Initial cytotoxicity testing of the PA in Calu-3 cells in a submerged setup and under ALI conditions indicated the absence of toxicity. In addition to toxicity testing, tools for visualization and quantification of MP particles in cells and biological matrices are being developed to study MP uptake and translocation. It could be shown that MP particles can be distinguished from lung cells by stimulated Raman spectroscopy. Furthermore, Stimulated Raman Scattering (SRS) Z-Scans confirmed the cellular uptake of PS plastic particles providing 3D visualization of PS distribution inside cells.

*__Dr. Tanja Hansen__ leads the working group "In-vitro Test Systems" at the Fraunhofer Institute for Toxicology and Experimental Medicine (ITEM) in Hannover, Germany. She has a background in veterinary medicine receiving her doctor's degree in 1998 from the University of Veterinary Medicine in Hannover. She is a veterinary specialist in pharmacology and toxicology. Her work focuses on the development and validation of cellular in-vitro models with emphasis on airborne substances and uptake by inhalation. Currently, Tanja is PI for the Cefic LRI project C10 a tiered strategy to assess microplastic inhalation.*

**Well-characterized nanoplastics for oral exposure studies in vivo**

*by Leah Johnson, RTI International*

A critical need exists to understand the toxicological responses and potential long-term health consequences of microplastics (MPs) and nanoplastics (NPs). The diverse properties of MPs and NPs, such as varied chemical compositions, size distributions, and morphologies, can challenge efforts to deduce how individual characteristics affect biological systems. At present, studies involving biological exposure to NPs have predominantly used commercially available spherical polystyrene (PS) nanoparticles. However, the potential toxicity of NPs comprising other globally dominant plastics or nonspherical shapes remain largely unknown, in part, due to the limited availability of these materials. This presentation will describe novel well-characterized NPs consisting of commodity plastics, with a focus on the oral route of exposure. We will briefly cover general approaches to fabricate NPs of commodity plastics as well as strategies to label NPs with tracers to ascertain spatial distribution both in vitro and in vivo. Using fluorescently labeled NPs (<200 nm) of polyethene terephthalate (PET) and polyamide (PA), our findings show the uptake of particles within macrophages (RAW 264.7), and clear morphological changes at certain concentrations, such as enlarged phagosomes and elongation of nuclei. The presentation will also cover in vivo findings from the oral, early-life exposure to PA NPs in Sprague Dawley rats. Pre-weaning male and female rat pups (aged postnatal day (PND) 7–10) were used as a model to evaluate the role of age and sex on biological responses, including basic cardiac assessments, neurotransmitter and related metabolite concentrations in brain tissue, and the endogenous metabolite profile in plasma. Lastly, we will explore challenges and key next steps required to understand the potential risks of NPs on human health.

*__Dr. Leah Johnson__ is the Senior Director of Biomedical Technologies at RTI International and holds nearly two decades of experience advancing polymeric materials for health applications and translation to early-stage prototypes. She currently leads a research team working on multiple government- and- privately funded programs to develop biomedical devices and nanomaterials for controlled drug delivery applications. Dr. Johnson's research group is developing biodegradable polymeric implants for medical indications, including the prevention and treatment of HIV, contraception, and as a multipurpose prevention technology. Using her experience with polymers and nanomaterials, Dr. Johnson has recently spearheaded novel efforts to address the biological exposure to nanoplastics. She is designing and fabricating novel nanoplastics with well-characterized profiles to unravel how the multifaceted characteristics (e.g., size, shape,*

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| | *composition) of nanoplastics can affect biological systems. Prior to joining RTI in 2012, Dr. Johnson held a postdoctoral fellowship in the Department of Biomedical Engineering at Duke University where she developed a bio-separation process for acoustic-mediated rare cell isolation and a triggered release system for tissue engineering applications. She has also served as a patent analyst at Lathrop & Gage Law Offices and held a research position at Gilead Sciences. Dr. Johnson loves skiing, running, and spending time with her dogs, Hans and Ruby.* |

## A risk assessment framework for microplastic particles

**Risk assessment of microplastic particles for human health and environment, a probabilistic view**
*by Bart Koelmans, WUR*

Microplastic risk assessment is a complex task. As a result, many assessments to date have compared apples to oranges, with exposure and effect assessments not aligning, while data quality has often been limited. Recently, QA/QC and standardization methods have been developed to alleviate some of these problems, although some degree of uncertainty always remains. In this presentation, we summarize the essentials of recent methods for performing a consistent risk assessment and provide examples of new risk assessments for microplastic effects in marine systems, freshwater, sediment, and soil, and microplastic effects on humans.

***Dr. Bart Koelmans** is an environmental chemist and ecotoxicologist by training and heads the Department of Aquatic Ecology and Water Quality at Wageningen University. In the field of plastics research, his group combines conceptual modelling and empirical approaches to gain a mechanistic understanding of the risks posed by microplastics to human health and the environment. Bart is a global highly cited researcher (Clarivate Analytics), advises international organizations like the World Health Organization, led international working groups about risks of plastic pollution, such as the European Commission's Science Advice for Policy by European Academies (SAPEA) expert group on Microplastics in Nature and Society, and is Editor-in-Chief of the new journal Microplastics and Nanoplastics. For more information, see www.microplasticlab.com.*

**Lost in parameter space – Can we reduce the complexity in microplastic research?**
*by Holger Kress, University of Bayreuth*

The investigation of potential harmful effects of microplastic on organisms is challenging due to the huge parameter space in microplastic research. Microplastic particles can vary significantly based on polymer type, chemical modifications, shapes, and sizes. Furthermore, model organisms and investigated effects can be chosen from a large variety of options. Each individual study can therefore only cover a very small volume of the resulting huge multidimensional parameter space. Indeed, the parameter space is so large that it is even for the whole research community challenging to cover a notable fraction of it and to make individual studies still comparable to each other. Therefore, it would be very helpful to reduce the complexity in microplastic research. One approach to achieve this is to search for a small set of key parameters that are crucial for the interactions between microplastic particles and organisms. On the side of the organisms, complexity can be reduced by looking first at the basic building blocks of all living beings, single cells. The interactions between microplastics particles and cells strongly depends on the surface of the particles. Therefore, we investigated the influence of the surface properties of microplastics particles on their adhesion to cells and their internalization into cells. At first, we found that previous environmental exposure of particles strongly influences their interactions with cells. At first glance, this finding increases the complexity in microplastics research because it adds "history of the particle" as a new dimension in parameter space. However, more recently, we gathered evidence that a single physical parameter – which varies drastically between different particles – strongly influences the interactions between particles and cells. We hope that this parameter can significantly contribute to a reduction of the complexity in microplastic research.

***Dr. Holger Kress** studied physics at the University of Heidelberg. From 2002 until 2006 he worked on his PhD in a biophysics research group at the EMBL (European Molecular Biology Laboratory) in Heidelberg. During that time, he already got interested in the interactions between plastic microparticles and living cells. However, the intention of this work was not to investigate the possible threats of microplastic, but to study the process of phagocytosis by which cells engulf foreign objects. During his postdoctoral stay a Yale, he used polymer microparticles that provide a controlled release of chemicals to stimulate cells a spatially and temporally flexible way to study cellular signal processing. After a short time as assistant professor at the Eindhoven University of Technology, he started in 2012 as professor for biological physics at the University of Bayreuth. Since 2019, he works in the Collaborative Research Center on Microplastics at the University of Bayreuth.*

**Assessing risks of microplastics in drinking water and the aquatic environment to inform risk management strategies in California**
*by Scott Coffin, California State Water Resources Control Board*

Concerns regarding widespread contamination of microplastics prompted the California legislature in 2018 to pass legislation aimed at monitoring and managing the human health impacts in drinking water and impacts to coastal ecosystems. These laws (Senate Bills 1422 and 1263) require the State Water Resources Control Board and the Ocean Protection Council to develop standardized analytical monitoring methods, assess risks to humans and aquatic ecosystems, perform monitoring to determine exposure to humans and contamination in the environment, and recommend policy strategies to reduce further contamination. Fulfilling these policy and regulatory goals requires research to fill scientific gaps in this rapidly emerging field.
While the health impacts of microplastics in aquatic organisms have been relatively well-documented, evidence for impacts to humans are limited and rapidly emerging. We convened an expert workshop to develop frameworks for assessing microplastics' risks to humans and ecosystems and applied this framework to the available literature. Hazard studies were screened for quality criteria prior to undergoing additional expert evaluation and studies passing minimum criteria were deemed fit-for-purpose. Of the 29 in vivo mammalian toxicity studies on microplastics, twelve were deemed fit-for-purpose, of which seven reported adverse effects on male and female reproductive systems. Although no single study met all quality criteria necessary for risk assessment, consistent trends were observed between studies, with inflammation and oxidative stress identified as likely mechanisms of toxicity. While we were able to derivate a human health-based threshold for microplastics, the value is highly uncertain due to incomplete exposure information and unknown differences in toxicity between polymers and shapes. Our expert workshop also identified 167 toxicity studies for microplastics in aquatic organisms, of which 21 were deemed fit-for-purpose. Multiple risk-based thresholds were developed that correspond to increasing certainty in adverse ecosystem impacts and suggest increasing levels of response from governments. Comparisons of thresholds to monitoring data in San Francisco Bay suggest early signs of ecosystem impairment with a moderate degree of certainty.

*__Dr. Scott Coffin__ has a PhD in environmental toxicology and serves as a Research Scientist at the California State Water Resources Control Board, where he leads development of regulations and policies regarding microplastics. Dr. Coffin has been researching impacts of microplastics on biota since 2014, and serves as a journal editor for Cambridge Prisms, and Frontiers.*

**Human health risk frameworks - needs for human health microplastics risk assessment**
*by Raymond Pieters - Utrecht University*

The EU project POLYRISK (https://polyrisk.science) aims to establish a fit-for-purpose risk assessment framework for assessing human health risks of micro- and nanoplastic particles (MNPs). The final framework will be available at the end of the project (March 2025). The major focus in the POLYRISK project is the inhalation exposure route, where substantial knowledge and concepts from (nano- ) particle toxicology can be considered as a starting point.
The conceptual framework proposes to distinguish micro/nano-sized fibres, polymers and particles and will make use of effect data of MNP on inflammation-related key events (cell stress, release of proinflammatory mediators, and activation of immune cells) and of human exposure and effect data from real world human scenario studies.
The current status of the POOLYRISK project will be presented to demonstrate challenges and solutions for data collection.
*Acknowledgement: POLYRISK project has received funding from the European Union's Horizon researcj and innovation programme under grant agreement No 964766*

*__Prof. dr. Raymond Pieters (PhD)__ is an expert on immunotoxic effects of substances (e.g. drugs, particles) with regard to inflammatory responses and diseases. He is partner in the Dutch Momentum project on micro- and nanoplastics and also leads the EC-project POLYRISK, to develop knowledge and approaches to assess human health risks of micro- and nanoplastics.*

**Case Study – Microparticle monitoring at the Seattle Aquarium: Life before and after Covid-19**

*by Veronica Padula, Seattle Aquarium*

As awareness and concern over microplastic pollution has grown over the last decade, so has the need for ongoing monitoring programs that can track microparticles in water bodies to better understand sources, distribution patterns and environmental factors that influence these patterns. This is especially true for Puget Sound, whose geographic diversity ranges from heavily populated urban areas to dense wilderness, but whose overall ecosystem health is intensely impacted by human activity and waste input. The Seattle Aquarium maintains a water monitoring program in which the water that is incoming into the Aquarium from Elliott Bay is monitored for the presence of microparticles such as microplastics and microfibers. Our microparticle monitoring program has been active since 2019, and an analysis of our data from 2019 and 2020 found a sharp decline in microparticle concentration in April 2020, a timeframe approximately coinciding with the start of Covid-19 restrictions, including stay at home orders and limited travel. While we initially believed seasonal fluctuations in environmental factors such as precipitation, river discharge and sewage overflow would most heavily influence patterns of microparticle concentrations in the data, Covid-19 restrictions played the most influential role in the drop in microparticle concentration in 2020. Since that time, we have continued our microparticle monitoring efforts, capturing not only the start of the Covid-19 pandemic but the gradual lifting of restrictions since that time. Preliminary data analysis suggests high variability in microparticle concentrations following April 2020, with several high spikes throughout the sampling period, which may be related to human activity such as the lifting of Covid-19 restrictions and construction around the Seattle Aquarium.

***Veronica Padula*** *earned her undergraduate degree in Ecology, Evolution, and Environmental Biology from Columbia University in New York. She discovered her passion for wildlife research during the summer between her junior and senior years, when she was a research intern for Wildlife Trust, investigating the overall health of black-crowned night herons living in the New York Harbor. Her undergrad mentor offered her a position on a project in Alaska the following year, and although she had never really considered Alaska before, she was ready for adventure and accepted the offer. It was perhaps the best decision she could have made. In 10 years since moving to Alaska, Veronica earned her Master's and PhD in fisheries. Her Master's research investigated the genetic relationships of least cisco, a whitefish species that is broadly distributed across Alaska. Her PhD research explored the impacts of plastic marine debris on Bering Sea communities and ecosystems. During her PhD, Veronica worked as the Science Education and Communication Specialist for the Aleut Community of St. Paul Island Ecosystem Conservation Office, where she coordinated science programs for students and led community-based research. She recently started a position as Research Scientist at the Seattle Aquarium. Veronica believes anyone can be a scientist, and she hopes that by spreading her love and passion for all things science, she can make the field more accessible to everyone.*

**Wednesday 14 June – Additives workshop**

## Overview of chemical additives & Risk based scientific principles

**Additives in polyethylene and copolymers**
*By Alexander Williamson, Dow*

Plastics are an integral part of almost all aspects of modern life. Polyethylene is one of the most common plastics due to its low cost, structural versatility, and high performance, and is used in a wide variety of applications such as shopping bags, food packaging, water pipes, cables, rigid containers, and many more. Most types of polyethylene contain additives in order to realize their full potential. A wide variety of additives are used in polyethylene, with functions such as protection from thermal or UV degradation, processability, flame retardancy, and enhancement of the performance of the plastic. A high level overview of the most common additives used in polyethylene will be provided.

*__Dr. Alexander Williamson__, Principal Research Scientist, Dow Packaging & Specialty Plastics (P&SP) Research and Development, has a background in material chemistry / material science and has worked in a wide variety of fields in the industry including gas-phase polyethylene resin design, high pressure copolymers, and wire & cable compounds. He is a subject matter expert in the area of Additives in polyethylene (copolymers). Before P&SP, Alex was based in Core R&D working with several other Dow businesses. Alex has a PhD in Organometallic Chemistry.*

**The role of additives in a circular plastics economy**
*by Ricarda Fieber, ETH Zurich (online)*

Increasing plastic pollution is a topic of global concern. The ongoing negotiations to develop a global plastics treaty to end plastic pollution show strong interest in circular approaches, particularly in recycling. However, a research gap exists when it comes to the environmental impact of increased recycled content in plastic products. More precisely, over 13.000 chemicals are currently used in the plastics lifecycle, of which the majority are additives. While additives are used to enable useful if not critical product functionalities on one side, certain additives used in plastics are suspect of being toxic and hazardous for human health. Knowledge about additives is especially limited when it comes to multiple cycles of usage. The accelerating transition towards more circular plastics systems design requires a deep understanding of potential threats and opportunities stemming from additives. Therefore, this presentation aims to present the findings of first investigations in both, challenges and opportunities of additives in a more circular plastics economy, starting with an analysis of the broad range of understandings of the role of additives in a linear but also a circular economy.

*__Ricarda Fieber__ is a Project Manager in sus.lab (Sustainability in Business Lab) and a Researcher in the Group for Sustainability and Technology (SusTec) at ETH Zurich. Her research broadly focuses on topics related to circular economy and plastics. Currently, Ricarda focuses on the analysis of plastic additives and their role in a safe and sustainable circular plastics economy. Prior to her position at ETH Zurich, she completed her bachelor's degree in Industrial Engineering, particularly focusing on Materials Science and Materials Resource Management. In her masters from the University of Augsburg, Germany, and UC Berkeley, US, she majored in Management and Sustainability.*

**LRI ECO58 - Comprehensive additive release and bioaccessibility model for risk assessment of micro- and nano-plastics in the environment**
*by P. Lee Ferguson, Duke University*

The ubiquitous occurrence of plastics in natural waters is a consequence of vast and increasing utilization of synthetic polymers in commercial, industrial, and consumer applications. While the implications of continuous ecological exposure to plastic particles in the nano- to micro size range (i.e. micro- and nanoplastics, MNP) have been studied extensively, a significant gap remains in our understanding of polymer additives and their fate in the environment during and after plastic particle release. Additives may include synthetic organic chemicals such as dyes, antioxidants, UV inhibitors, plasticizers, and other performance-based chemicals added during or after polymerization to enhance or protect the polymer in its intended application. Also, surface coatings such as water/stain repellents (e.g. polyfluorinated alkyl substances) may be added to polymers (in particular synthetic fabrics) before use. Incomplete polymerization or polymer degradation of some plastics during/after disposal may also release residual or regenerated monomers, oligomers, and polymer breakdown products, which although not strictly "additives", may pose an exposure risk to ecological receptors. Comprehensive risk assessment of polymer additives in the aquatic environment depends critically on the ability to measure and subsequently predict exposure of sensitive receptors to these materials. Robust models are needed to assess leaching of additives and other polymer-associated chemicals (PAC) from plastics into water and digestive environments encountered by nano-/microplastics ingested by organisms. We have created a robust and generalizable model to predict polymer additive release, transformation (where relevant), and bioaccessibility in context of realistic aquatic environments. This model is based on chemical and physical properties of chemical additives, polymer materials, and leaching environments, and has been parameterized through both incorporation of existing data available for these properties and data generated through laboratory experimentation. We will discuss results of additive leaching experiments from multiple micro- and nanoplastic types and will demonstrate the utility of our leaching model within context of additive release into aqueous media and bioaccessibility scenarios.

*__Dr. P. Lee Ferguson__ is an Associate Professor of Environmental Science and Engineering at Duke University in Durham, NC. He received B.S. degrees from the University of South Carolina in Chemistry and Marine Science in 1997 before earning a Ph.D. in Coastal Oceanography at State University of New York – Stony Brook in 2002. His postdoctoral research was conducted in the area of proteomics at the Pacific Northwest National Laboratory in Richland, WA. Before joining Duke, Dr. Ferguson was an Assistant and Associate Professor of Chemistry at the University of South Carolina.*

*Research in the Ferguson laboratory is focused on Environmental Analytical Chemistry. Specifically, a major thrust of research in the lab involves the application of high resolution mass spectrometry to detect, identify, and quantify emerging contaminants in wastewater and drinking water. His recent work has centered on the development of non-targeted analysis workflows and methods, assessment of polyfluorinated alkyl substances in water and wastewater, and leaching and bioaccessibility of polymer-associated chemicals from microplastic particles in the aquatic environment. He has published over 90 peer-reviewed chapters and journal articles, serves on advisory councils for several organizations focused on emerging pollutants in the environment, and has testified before the U.S. Senate on environmental health concerns related to nanotechnology. In North Carolina, he helped lead the formation of the NC PFAS Testing Network to assess statewide drinking water contamination from PFAS chemicals.*

**U.S. regulation of food contact substances and microplastics implications**
*by Katie Skaggs, Keller and Heckman LLP*

The presentation will provide an overview of the way the U.S. Food and Drug Administration regulates food additives, including food contact substances used in applications like food packaging. It will explain how FDA typically thinks about potential dietary exposure to food contact substances, and the information generally needed to assess if a food contact substance has a suitable FDA status. The presentation will explore how microplastics fit into the FDA food-contact assessment paradigm. The talk will touch on new questions being raised about microplastics arising from recycled and compostable food-contact articles, which are growing in prevalence due to technological advances and regulatory pressure. It also will cover actions by FDA and others that are targeted at reducing microplastics.

*__Katie Skaggs__, a partner in Keller and Heckman's food and drug practice, is an expert in the regulation of food contact materials in a host of jurisdictions including the U.S., EU, and China. Katie assists companies in bringing to market new food contact materials, such as plastics, biopolymers, paper, adhesives, coatings, recycled materials, and components of these materials through submissions around the globe. She also manages post-market issues for food contact materials. Katie advises on a range of state legislation that impacts packaging, including California's Proposition 65, as well as laws on extended producer responsibility for packaging, bans on PFAS in food packaging, and minimum recycled content mandates. Katie is the co-host of "Food & Chemicals Unpacked," Keller and Heckman's podcast regarding the legal and scientific issues surrounding the food, chemical, packaging, and related consumer product industries.*