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Plastics in the Environment – Author Perspectives – Part 2 of 2

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In 2020, PLOS ONE published a Collection of research entitled Plastics in the Environment, submitted to a Call for Papers on this important topic. A year later, we are checking in with some of the authors who are a part of this collection, to hear their thoughts on where this research field is headed, and what all of us can do to support their work.

In this second installment of two, we hear from Lars Hildebrandt (Helmholtz-Zentrum Hereon), Bishal Bharadwaj (University of Queensland) and Anton Astner (University of Tennessee, Knoxville). They discuss the importance of open sciences practices to tackle global challenges, sustainable alternatives to plastics in various settings, and the challenges posed by the lack of methodological standards.

What inspired you to want to work in this field? What path did you take to where you are today?

LH: I am inspired by the fact that sound research into environmental particulate plastics, i.e. nano- and microplastics, is extremely demanding analytically on the one hand and highly relevant to society on the other. The social consequences are less abstract than with respect to other chemical-analytical topics. From my point of view, the biggest problems for nano- and microplastics research is the lack of methodological standardization. Consequently, the available studies are hardly comparable. To draw an accurate picture of the real environmental situation, scientists focusing on particulate plastics need to agree on high chemical-analytical and metrological standards. It inspires me to contribute one small piece to this important step: the method that my colleagues and I published in PLOS ONE enables the accurate and metrologically-traceable analysis of trace metals in/on plastic particles. I originally studied Chemistry and Business Studies and entered the field of particulate plastic monitoring through my master thesis. During my PhD thesis at the Helmholtz-Zentrum hereon, I deepened the work and added more aspects to it such as interactions between particulate plastics and trace metals.

BB: After graduating from school in 2001, I proposed my to friends that we do a volunteer cleaning campaign in Ilam (my hometown). We cleaned several places and realized plastic is a menace. It blocks drains and pollutes water sources. This realization motivated us to work against plastic pollution. Then we registered a youth-led NGO with an objective to lobby for a plastic bag ban and work for a clean and green city. Ilam municipality declared a ban on the use of single-use plastic bag in 2010. Other municipalities followed suit. However, the effect was mixed. I was intrigued by the question of ‘why does a plastic ban works in some municipality and not in the others?’ In 2013, SANDEE—a research network in South-Asia, provided a research grant to investigate the question. The study result showed that appropriate policy and its enforcement are key to the effectiveness of the ban. From this study I learned that the ban is helpful but not sufficient to tackle plastic pollution. Working to reduce plastic encouraged me to

learn about other aspects of plastic pollution such as the circular economy and behavioural change.

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>
> Lars Hildebrandt

AA: My early life's first strong impact was in first grade in Elementary School when our General Biology teacher took our class out for a field trip to collect disposed environmental trash in our town. This hands-on experience opened my eyes, and I realized that plastic debris disposed into the environment is not only aesthetically disturbing; it also may pose harm to terrestrial and aquatic habitats, wildlife, and humans. At this point, I started realizing how biodegradable engineered plastics derived from natural resources could help to reduce the environmental impact through pollution. Another part of this sustainable thinking I have experienced through the family-owned sawmill business. The conversion of logs into lumber yields virtually 100% product recovery by utilizing the main products, slabs, and sawdust. This experience instilled in me to learn more about renewable materials and natural resources.

The following education in Forest Products Technology & Management at the Salzburg University of Applied Sciences (SUAS), Austria biobased materials, improved my sustainable thinking by efficiently converting and utilizing the lignocellulosic materials.

I have learned the crucial steps for successfully conducting research and developing new products by collaborating with companies during this study. An internship at the Center for Renewable Carbon at the University of Tennessee, Knoxville (UTK), was one element of my overall academic highlights as an undergraduate student from the SUAS, which has paved the way for the joint venture graduate degree between UTK and SUAS for the following years.

In the subsequent years, I have researched as an associate at the Center for Renewable Carbon and the Department of Biosystems Engineering and Soil Science (BESS) department at UTK. Under the supervision of Professor Dr. Hayes, I have gained excellent expertise in conducting research, the publication of research results, and collaborating with a team of students, faculty, and staff.

What do you see are the biggest hurdles that we need to overcome in order to tackle plastic pollution in the environment?

LH: A broad understanding is required that we, humanity, have to stop handling giant masses of plastic waste too carelessly and recklessly. Only global attempts to foster real circular economies, wide usage of biodegradable plastics for packaging and omission of persistent plastic products with a very short lifetime can solve the problem. I want to underline that the plastics used for products with short lifetimes should be really biodegradable and not only a "smart marketing trick". Additionally, we have to find a way to produce them efficiently in terms of resource consumption.

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Lars Hildebrandt

BB: When I was a kid plastic was not as common as it is today; people used paper pouches, jute bags, iron buckets and wooden chairs. All these things are made of plastic these days. This rapid increase in plastic use with no concrete action is a concern.

We use plastic for short-term convenience, then throw it away for long-term harm. Plastic looks cheap and convenient. But what about the social cost associated with its carbon emission and the environmental damage for centuries? There is a lack of global commitment against plastic pollution. Although diverse sets of programs are under implementation, many of these are local in scale. For instance, bans or levies on single use plastic bag are typically implemented at the municipality level. We do not see any countrywide regulation or agreement at regional level. Is the knowledge that there are micro-plastics in table-salt insufficient to act against plastic pollution at a global level? If so, until when will we be able to ignore this problem? Why are governments allowing this rapid march to common tragedy? We do not have clear answer to so many questions. This poor understanding is a known challenge.

AA: Most important is to understand all phases of the plastic materials' "life cycle" — from creation to utilization to disposal. Therefore, it is crucial to find new ways to reduce waste and better protect the environment and communities. In this context, scientific research can contribute to understanding the critical aspects of the plastic problem. New technologies and

product designs, such as developing novel and environmentally benign biodegradable materials, will also be an inherent part of reducing plastic waste.

In agriculture, plastics are frequently used for the cultivation of plants and to increase crop yields. Plastic mulch films are essential materials for the sustainable production of vegetables and other specialty crops by elevating soil temperatures, conserving soil moisture, controlling weed growth, and providing protection against severe weather impacts. However, polyethylene mulches are the most used conventional mulch film materials and are lacking sustainable disposal methods. Improperly disposed materials form smaller particles through environmental impacts (sunlight, wind) and trigger gradual fragmentation into micro- (MPs) and nanoplastics (NPs). These small particles may remain in the soil, be mobilized, and distributed by wind, transported via surface run-off to the aquatic environment posing a severe threat to ecosystems.

In recent years, biodegradable plastic mulches (BDMs) became important in the sustainable production of vegetables and other specialty crops, designed to be inexpensively plowed into the soil, where they will fully biodegrade into carbon dioxide, water, and cell biomass.

Our current research focuses on understanding the implications of biodegradation in the field during and after the growing season, the formation of MPs and NPs, and the fate and impact on terrestrial ecosystems.

What are the areas where you see promise for helping us deal with plastic pollution? Either in the short term or long term?

LH: The research about the presence and toxicity of particulate plastics as well as their interactions with co-pollutants is important since it increases the awareness of plastic pollution in general. However, only the consumers and politics can initiate action by the decisive economic sectors. On the one hand, the products should be designed in a smart way that facilitates recycling, which is definitely possible. On the other hand, we have to streamline the recycling system and expand its capacities – especially in countries with alarmingly low recycling rates and high shares of plastic waste discharged directly into the environment.

We use plastic hundreds of times a day without knowing we used it. What this indicates is that plastic use is deep in our habits and replacing it needs convenient but environmentally friendly substitutes. Finding a substitute is not easy because plastic provides a wide range of advantages to different sectors.

Bishal Bharadwaj

BB: Inaction against plastic pollution is partly contributed to by the poor knowhow about the social cost of plastic use. We use plastic hundreds of times a day without knowing we used it. What this indicates is that plastic use is deep in our habits and replacing it needs convenient but environmentally friendly substitutes. Finding a substitute is not easy because plastic provides a wide range of advantages to different sectors. We need more research in all aspects of these aspects. However, having a substitute is not enough; economic incentives and behavioral measures are equally important to replace plastics in daily life. Therefore, an integrated approach is crucial. An integrated approach demands a collaborative engagement of researchers from different fields. Behavioral science, for instance, may suggest an intervention to change the plastic use behavior whereas chemical engineering can provide insights about the sustainable substitute of plastic. We need industry, policy makers and civil societies to take the innovation from labs to our households.

AA: In many countries worldwide, governments, communities, businesses, academia, and researchers work diligently to find solutions and new ways to tackle our global plastic pollution problem. The short-term actions reach from the reduction of single-use-plastics (banning plastic straws, styrofoam containers), implementing efficient waste collection, and conducting research in terrestrial and marine habitats.

In the long term, it will be required to include all “players” in a joint effort to increase awareness of plastic pollution and its consequences by shifting from typical one-way commodity plastics to more environmentally benign materials such as biodegradable/compostable materials.

For agriculture, in the face of increased interest in organically-grown plants and crops, I see a considerable potential for sustainable-oriented farmers who are also encouraged to employ environmentally friendly farming practices.

How important are open science practices in your field – e.g. data sharing, code sharing, protocols sharing, preprints etc.?

LH: I hold the opinion that open science practices are mandatory in environmental research to maximize its outreach. Ultimately, taxpayers finance most of the work. Thus, access to the results must not be denied to anybody.

BB: Plastic use behavior is a mix of interlinked factors. We cannot tackle plastic pollution only through local action such as municipality bans or product-specific intervention such as targeting plastic straws. These small-scale initiatives are helpful, but plastic has now become a major element of global trade. Therefore, research and collaboration among all concerned

stakeholders is necessary. Research from one field will become a steppingstone for other fields to develop a workable solution. For instance, a chemical engineer can use social science on consumer preferences for a bag to find an effective substitute. This synchronized effort needs open science practices. I am impressed with our open science practice in COVID-19 research and information. The main takeaway from this COVID-19 practice is that open science is crucial to tackling global problems.

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Bishal Bharadwaj

AA: Data archiving and sharing with the scientific community is an inherent part of conducting successful research. Therefore, data storage and preservation, and publication will be essential. I believe that data sharing can catalyze new collaborations, increase confidence in findings, and serves as a basis for making progress in specific research areas. Our fundamental research area is essential since the detection and characterization of MPs and NPs lack standards. Therefore, data and information exchange are crucial to building on implementing standardized procedures for peer researchers gradually. Furthermore, using a digital object identifier (DOI), data sets are becoming easier to cite and independently discoverable. This “citability” gives researchers credit for their data sets and allows researchers to list them on job, tenure, and promotion applications.

How does interdisciplinarity fuel your work? Do you often collaborate with researchers from other fields or others outside of academia?

LH: Working in an interdisciplinary network fuels the overall impact of research on particulate plastics. For instance, analytical chemists must collaborate with biologists and toxicologists since a risk assessment comprises assessment of the exposure and evaluation of the toxic effects as well as effect levels (e.g. LOEC) of a pollutant. In a larger context, microplastic researchers should also cooperate with social scientists to convey the key messages that can be derived from their specific findings. Even if we massively reduce the global discharges of plastic waste into the environment, the fragmentation of the giant amounts of plastics present in all aquatic compartments will continue. One of these messages could be: Action that we take today to tackle plastic pollution might need decades to “become visible”.

BB: Like other environmental problems, the fight against plastic pollution also requires a) identification of workable solutions and then b) their implementation. Initially I started my journey from civil society where we lobbied for a ban and worked on social mobilization against plastic bags. While working in the environment management section of the Ministry of Local Development I realized the complexities of environmental policies and its implementation. That is why, as a researcher, I tried to answer questions that are helpful for policy makers. However, collaboration between academia, industry, civil society, and governments will expedite the fight against plastic pollution. If policy makers or industry, for instance, identify the knowledge gaps on plastic pollution, then researchers can help to fill them.

AA: Collaboration across different disciplines is crucial in our field of research. In particular, our research areas involve the scientists' expertise in biosystems and biomolecular engineering, soil physics, polymer science, chemistry, statistics, and nuclear engineering. Our research team regularly interacts and collaborates with researchers within our academic departments across campus. Our particular research also involves collaboration with the Oak Ridge National Laboratory, focusing on NPs detection in soil by employing Small-Angle Neutron Scattering (SANS) techniques. Interdisciplinary research allows the synthesis of ideas and characteristics from many disciplines, developing essential, transferable skills.

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>
> Anton Astner

What advice would you give to someone who is interested in helping with the efforts to reduce plastic pollution – whether as a researcher or a private citizen? How can the rest of the world support the work that you and your colleagues do?

LH: Every private citizen as a consumer has an impact. If we start being very critical about our own behavior when it comes to single-use plastics and plastic beads in cosmetics, for example, the companies will adapt their practices. Actually, there are many parallels to other topic such as the interlink between meat consumption and animal welfare. Sustainability might be an "overused" word in a way. Nevertheless, it starts with everybody's (consumer) behavior.

BB: We can contribute in several ways. First, being a responsible consumer, we can make a difference. Using reusable bags will reduce the billions of single-use plastic bags. This behavioral change is possible in many dimensions of our day-to-day life, such as straws and coffee cups. Second, even if it is necessary to use plastic, it does not take much effort to make sure the used plastic enters the recycling process. Thirdly, we can contribute from where we are working. For example, an agriculture scientist can investigate the ways to reduce or replace plastic wrapper for cucumbers. Fourthly, being a responsible human being lets us gather evidence and raise our voices for global treaties against plastic pollution as we are doing for climate change. To summarize, let us take plastic pollution seriously and try our best to fight plastic pollution before it is too late.

AA: An annual amount of eight million metric tons of plastic waste enters the oceans each year, and predictions estimate by 2050 that the amount of plastic in the oceans will have more mass than all fish. The consequent reduction of plastic product utilization can avert this concerning prediction by employing reusable shopping bags, opting for clothing made of cellulose, hemp, wool, and other natural fibers, and choosing products packed in natural raw materials such as corn starch or cotton, just to mention a few options.

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As a researcher, I encourage farmers to employ sustainable farming by opting for sustainable plant cultivation using environmentally benign materials such as biodegradable plastics (mulches) to reduce waste. Furthermore, I motivate communities to avoid plastic waste by creating public awareness and implementing recycling practices, e.g., rigorous waste separation.

In recent years, MPs and NPs have received considerable attention regarding fate and pollution to the various environmental compartments. The long-term fate of plastic fragments in the soil is unknown. Our fundamental research aims to understand the life cycle, the ecotoxicological fate of MPs, and NPs for plant and soil organisms in subsurface agroecosystems. The outcome of our research may provide a pathway for current and prospective researchers interested in understanding the implications and fate of MPs and NPs in the terrestrial environment.

About the authors:


KLM

Lars Hildebrandt: Lars studied Chemistry and Economics at Kiel University (B.Sc. and M.Sc.). In 2017, his master thesis dealt with microplastics in marine sediments. During his PhD work, which he finished in March 2021 at the Helmholtz-Zentrum Geesthacht, he focused on Nano- and Microplastics as well as the particles' interactions with trace metals. Currently, he works as a postdoc at the Helmholtz-Zentrum hereon and his research focus is still on environmental particulate plastics as well as trace metals.

Bishal Bharadwaj: Bishal Bharadwaj has worked in environment management and policy for more than a decade. In 2001 Bishal and his friend established an NGO, with the aim to lobby for a ban on plastic bag use and mobilize youth to tackle plastic pollution. Bishal also served in the Government of Nepal, and worked on the Initial Environmental Examination Review committee

of Ministry of Local Development and the Environment Friendly Local Governance Framework in 2013. Bishal's research interests is in the evaluation of environmental policies. He is currently doing PhD at the University of Queensland, where his research aims to understand the influence of decision context on energy access at the subnational regions of Nepal.

Anton Astner: As a native Austrian born in Salzburg, Anton graduated from the Salzburg University of Applied Sciences (SUAS) in 2009, and with a master's degree in Natural Resources at the College of Agricultural Sciences and Natural Resources at the Center for Renewable Carbon in 2012. In 2017, he started as a Research Associate in the Department of Biosystems Engineering and Soil Science (BESS) at the Institute of Agriculture, University of Tennessee Knoxville, under the supervision of Prof. Dr. Douglas Hayes in collaboration with the Oak Ridge National Laboratory (ORNL) with the focus on the formation and dynamics of micro- (MPs) and nanoplastics (NPs) in the agricultural soil environment. In the fall of 2018, he started pursuing a Ph.D. degree at the BESS department in a joint effort with ORNL, investigating the interactions and fate of MPs and NPs in the terrestrial environment.

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Featured image: Marine debris litters a beach on Laysan Island in the Hawaiian Islands NationalWildlife Refuge, where it washed ashore. (Susan White/USFWS) CC-BY

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