German Environment Agency

Microplastics in soils – a threat for human health and the environment?

International Conference Berlin, 19 - 20 October 2022, Berlin and online

Abstract Book

1 Abstracts (1st day)

1.1 Entries, occurrence and distribution of microplastics in soils

Author: Christian Laforsch

Affiliations: University of Bayreuth

Abstract: The ubiquitous contamination of the environment with microplastics and the associated risks to ecosystems and potentially human health has recently attracted a great deal of public and scientific attention. In the past few years, the research focus has shifted from a purely marine perspective to include microplastics in freshwater systems and now soils. Due to the fact that soils are a relatively new field in microplastics research, the data pool is still limited, and many studies are not comparable due to the use of different sampling-, sample preparation- and analytical methods. Nevertheless, many microplastic input sources into soils have been identified, such as agricultural practices: E.g. the use of mulch foils, application of sewage sludge or compost derived from municipal biowaste, certain irrigation practices and the application of coated fertilizers. Additionally, storm water runoff and flooding may be input pathways for microplastics into soils, as are diffuse sources, such as littering and atmospheric deposition. Depending on the land use, soils are exposed to varying levels of contamination – thus urban soils generally show higher concentrations of microplastic contamination than more rural soils, and contamination in agricultural soils shows an extremely high variation depending on the agricultural practices performed in the area. Additionally, erosive forces such as wind and rainfall but also factors such as bioturbation or physico-chemical degradation affect the way microplastics are transported in the environment. Additionally, the shapes and sizes of the many different polymers that are implied in the umbrella-term “microplastics” significantly affect their transport and distribution in the environment.

1.2 Status quo of SOil Sampling for Microplastic Analysis (SOSMA)

Authors: Kristof Dorau, Martin Hoppe, Daniel Rückamp, Elke Fries

Affiliations: Federal Institute for Geosciences and Natural Resources, Hannover

Abstract: Determining of microplastics (MP) in soils has gained enhanced scientific attention in the last decade. This talk addresses current state of the art in terms of sampling and sample preparation to derive information on MP content in soils. We conducted a systematic literature

review by in-depth screening of more than 100 articles that focused to account for MP burden in soils (particle counts or masses). Most of these studies (63%) focused on known emission pathways with discrete study sites, whereas 37% targeted to delineate MP background contents due to fluvial, marine or aeolian MP deposition with de-localized MP emission sources. Thereby, 93% of the studies investigated the top 30 cm, which highlights the knowledge gap of MP abundance in the subsoil. Even though soil was the target medium, soil organic matter content, pH and texture were measured only in 20% of the studies. However, such basic soil parameters need to be considered in particular to evaluate analytical results for MP, e.g., of recovery tests. In terms of spatial distribution of soil samples, random sampling was applied more frequently than sampling of transects and raster sampling. In rare examples, the composite sample taken in the field was based upon a large representative elementary volume (REV) of several 100 kg that was reduced afterwards by quartering and mass reduction. However, the majority of studies followed common procedures where the mass of the composite sample (2.150 ± 1.150 g) constitutes merging of a distinct number of single samples (n = 5.1 ± 4.6). Larger REVs seem promising and might be an aspect to facilitate reproducible and representative analytical results, which needs to be validated for emission-specific MP pathways into soils. In conclusion, the systematic review revealed an incoherence in soil sampling and sample preparation within analytic protocols, which renders a comparison of results challenging.

1.3 Current methods for the detection of MP in soils – an overview

Authors: Carmen Wolf[1], Mike Wenzel[1], Björn Fischer[2], Jochen Türk[1]

Affiliations: [1] : Institut für Energie- und Umwelttechnik (IUTA) e.V.; [2] : Fischer GmbH – Raman Spectroscopic Services

Abstract: Research on microplastics has shown that they occur in all environmental compartments. Comprehensive data already exist for aquatic systems, while the database for soils and air is limited. A major challenge is the detection of microplastics in soils due to high background levels of other particles. There are different methods for the detection of microplastic particles. Spectroscopic methods (RAMAN, FTIR) provide information on the particle number size distribution, chemical identity and morphology of the particles, while thermoanalytical methods (pyrolysis or thermal extraction desorption gas chromatography mass spectrometry (TED-GC-MS)) provide information on chemical identity and concentration. While extensive sample preparation is necessary for the spectroscopic methods, reduced effort is necessary for thermoanalytical methods. In this presentation, different sample preparation methods that have been used for the detection of microplastics in soils will be presented and discussed. The challenges of microplastic analysis of soils will be shown using the example of the investigation of agriculturally used mulch films within the iMulch project.

TED-GC-MS analysis was performed after a density separation with sodium iodide followed by Fenton digestion, while a flotation device was used for the sample preparation for RAMAN spectroscopy. A major advantage of flotation is, that no chemicals need to be used, making it particularly sustainable.

With these sample preparation methods, it was possible to analyse the soils using TED-GC-MS and RAMAN spectroscopy. At iMulch only small amounts of polyethylene (PE) and the biodegradable mulch films (polylactide (PLA) with poly butylene adipate-co-terephthalate (PBAT)) were found in selected case studies. The results could not be linked to the type of cultivation of the soils. The complementary application of both methods is necessary to answer

research questions, whereas mass-based methods are probably advantageous for comparison of different locations and regulatory purposes.

1.4 The actual uses of plastics in agriculture across EU: Overview and environmental problems

Author: Ruth Pereira

Affiliations: GreenUPorto & Faculty of Sciences of the University of Porto

Abstract: European agriculture is each time more plastic dependent, in particularly in Southern Europe and, the different benefits of this versatile material are unequivocally presented by farmers and other stakeholders from the agri-food sector. From the "soil to the table" plastics are seen as crucial to reduce the use of herbicides, conserve water in the soil, avoid non-healthy soils, stabilize production conditions, preserve feed and to guarantee food transport and safety. Although studies on soils started later, the evidence of the impacts are clear at the laboratory, but less clear in the field, mainly in what regards soil functions and biodiversity. Nevertheless, some changes in soil properties, point for some possible impacts. Many farmers are aware of the problem and fearing legal enforcements. They want to be part of the solution, testing new materials appearing in the market, but no many alternatives are envisaged in a near future. Some new plastic materials, certified as recyclable, are a source of even more concerning issues, by giving rise to microplastics at the end of each production season, which cannot be removed from the soils, in opposition to the most resistant materials. The degradation of all these plastic residues is also questionable in impoverished soils, with impaired microbial communities, and at conditions different of those used for testing and providing certification. Countries collection systems of plastic wastes are also at a different status of development, and the price of plastic material stills not benefiting investment in research and on the implementation of an efficient recycling. Freeing European soils from plastic residues will be a utopia, therefore all the efforts must target the co-creation of new agriculture practices, materials, and recycling methodologies, in parallel with sensitization for a responsible use of plastics in all the steps of value chains.

1.5 Agricultural plastics as a source of microplastic pollution to soil ecosystems and crops

Author: Luca Nizzetto

Affiliations: Norwegian Institute for Water Research

Abstract: Agricultural plastics are gaining prominence on international agendas as research on "plasticulture" - reveals their advantages and trade-offs. The potential negative effects of plastic pollution to soil from agricultural plastics has drawn attention by the Food and Agriculture Organization and the United Nations Environment Programme. The upcoming International Negotiation Committee for a UN global legally binding agreement on plastic pollution will address this issue, too. Soil mulching produces agricultural and economic benefits to farmers and the food value chain. It is also seen as a technology that enable adaptation to climate change, by reducing water use in farming. While agricultural plastics are certainly not the only source of plastic pollution to agricultural soils, evidences point at measurable impacts on health and viability especially of soils that has received large loads of micro and nanoplastics, for example from post-use mismanagement of mulching films. Alternatives to conventional mulching films include synthetic biodegradable mulching films. While these are often showcased as greener

options, they introduce some concern too. The impact on soil health from their repeated applications is still poorly characterized and insufficiently addressed by the relevant EU standard (EN 17033). The EU research project PAPILLONS (Plastics in Agricultural Production: Impacts, Lifecycle and Long-term Sustainability) addresses the challenge of characterizing sources, behaviour and effects of micro and nanoplastic pollution from plasticulture covering both conventional and biodegadable materials. Ongoing research activities from the project and the early policy recommendations already provided by the project scientific consortium to the EU commission will be illustrated in the presentation.

1.6 Impact of microplastics on soils

Author: Matthias Rillig

Affiliations: Freie Universität Berlin

Abstract: Microplastics are a diverse array of contaminants that affect soil properties, processes and biota as a function of their properties, including polymer type, additives, shape and size. Adopting a global change perspective is useful, in addition to a more ecotoxicological vantage point, since the global change framework moves the focus to ecosystem-level consequences and feedbacks, interaction with other global change factors, future contaminant levels, and explicitly includes nominally positive effects. Plastic in soil has well-documented effects on soil structure, affect the soil microbial community, and the plastisphere is enriched for certain microbes, including potential pathogens and bacteria carrying antibiotic resistance genes. Long-term consequences are not well understood, and there may be a 'toxicity debt', i.e. toxic effects are slowly unfolding over time with increased weathering of particles.

1.7 Fate of microplastics in the environment

Authors: Violette Geissen, Nicolas Beriot, Ines Leitao, Loes van Schaik, Fabio Corradini, Meng Fanrong, Ke Meng, Foskea Raevel, Yueling Qi, Mahrooz Rezaei, Dirk Goossens, Esperanza Huerta Lwanga

Affiliations: Wageningen University

Abstract: The awareness of microplastics in the terrestrial environment has been tremendously increased in the past decade. Knowledge on the risk of the different polymers on the environment is **scarce** and risk related threshold values for MPs are missing.

We conducted a first survey study on European scale based on the LUCAS sampling in 5 countries showing median MP concentrations in agricultural soils ranging from 10 – 140 particles per g soil. In soils from urban and natural areas in Coimbra, Portugal we identified 5-571 MP particles per g soil. In all soils we identified different types of polymers. However, the analytical techniques are still in development and no defined protocol and validation exist. In the twin horizon 2020 projects MINAGRIS and PAPILLON we are working on a standardization of MP analysis.

The results of our survey studies lead to the questions of sources, transport processes, sinks and related environmental risk.

We identified MP concentrations in potential sources such as in Dutch compost, sludge from Chile, degradation of plastic mulch in Spain and China. Transport of MP by dust/ wind erosion and their deposition were identified in agricultural and urban regions. We tried to link the input

from the sources to the terrestrial MP pollution. Uptake in the terrestrial food chain was manifested in goat excrements grazing on Spanish agricultural fields under the use of plastic mulch after harvesting.

First risk assessment studies related to plant growth indicated negative effects of some biodegradable polymers.

We conclude that different types of MP polymers are omnipresent in the terrestrial environment with a severe lack of knowledge on environmental health effects. Regulations are urgently needed to reduce the use of single use plastics. Furthermore, risk related threshold values for MPs in water, soil and the air as well as in compost and sludge should be introduced and monitoring programs established. These measures are urgently needed to reduce the occurrence and risk of MPs in our environment.

2 Abstracts (2nd day)

2.1 Keynote - EU policy developments to prevent microplastic pollution

Author: Bavo Peeters

Affiliations: European Commission, Directorate-General for Environment

Abstract: Around 98% of primary microplastics are generated by land-based activities. In the end, 52% of these pollutants is released in the soil and 48% ends up in the oceans. Additionally, a significant proportion of plastic waste fragmenting into microplastics also enters the environment. At EU level, there currently is no single policy that addresses the problem of microplastic pollution of the soil and the environment in a comprehensive and integrated manner. EU strategies and legislations contain specific but fragmented measures across different policy domains to prevent the release of microplastics. Taking into account the growing scientific evidence and the increasing concern of citizens, the Commission is working on a number of measures and instruments to tackle microplastic emissions from all sources, as announced in the European Green Deal, the EU Soil Strategy, the Circular Economy Action Plan and the Zero Pollution Action Plan. Because the fate and effect of microplastics in soils remains still largely unknown, the presentation will also highlight some of the main policy needs and gaps in the knowledge and research on microplastics.

2.2 Nano- and microplastics policy: Regulations for sustainable plastics use and design

Author: Denise Mitrano

Affiliations: ETH Zurich

Abstract: The positive benefits afforded by the widespread use of plastics need to be reconciled with the negative impacts on the environment and health across the entire plastics life cycle.

Optimizing the balance in several facets of plastic production, use and waste management is necessary for a more sustainable relationship with these materials in the Anthropocene.

Restrictions on the intentional use of primary microplastics have been proposed or implemented in many places: what is the genesis of these regulations, what do they entail and how effective can they be?

In some instances, replacement of microplastics with alternative materials is technically simple and easily justified, but in others substitutions may come with more uncertainty, performance questions and costs.

Scientific impact assessment of primary microplastics compared to their alternatives relies on a number of factors, such as microplastic harm, existence of replacement materials and the quality, cost and hazards of alternative materials.

Regulations need a precise focus and must be enforceable by these measurements.

2.3 Analysis of microplastics in soils: Harmonisation and standardization - A first approach

Authors: Ulrike Braun[1], Korinna Altman[2]

Affiliations: [1] : German Environment Agency; [2] : Bundesanstalt für Materialforschung

Abstract: Standardized methods are needed to generate a valid database in environmental monitoring. They are mandatory for unambiguous identification of sources, fate and occurrence of contaminants and to derive meaningful measures for regulation.

Whereas for water matrices the process of standardisation has already progressed in ISO/TC147/SC2-JWG with the preparation of the ISO/WD 16094 series, but for soil and solid matrices is only at the beginning. However, in CEN/TC 444 first drafts are prepared, addressing especially the requirements for analysis of microplastics in soils.

The presentation will summarise the state of the art of standardisation and will go in research details addressing aspects of sampling, sample preparation and detection. The presentation will present first screening results for soils, achieved by projects of UBA "Plastic in Soils – Occurrences, Sources, Impacts" (FKZ 3717 72 2320). First data are shown and difficulties in developing methods and procedures are discussed. Based on this, needs for research will be derivate for future work.

2.4 Investigation on plastic pollution in agricultural soils and implementation of regulatory measures in Vorarlberg, Austria - A case study

Author: Katharina Sexlinger

Affiliations: Umweltinstitut Vorarlberg

Abstract: As in many other sectors, the importance of plastics in agriculture has increased enormously in recent decades. This is accompanied by an increased input of plastics into soils through agricultural practices but also through other input pathways. In the context of precautionary soil protection, questions arise about the handling of plastic contaminated soils. So far, there are only a few legal regulations concerning the input of plastics into soils.

Following several cases of soil contamination with plastics in Vorarlberg, plastic pollution increasingly became the focus of public and political attention. In the course of drafting the new Soil Protection Act for the state of Vorarlberg, limit and precautionary values for plastics in soil were defined. A simple and practicable method for the evaluation of plastic contamination was developed and several agricultural soils were examined. The results clearly showed that the use of secondary raw material fertilisers such as sewage sludge compost and digestate are leading to a notable input of plastics into agricultural soils.

Although the evaluation of plastic contaminated soils in the administrative practice is challenging and needs to be further improved, it is a necessary tool to regulate plastic pollution of soils. The actual impacts of microplastics in soils are still largely unclear, yet immediate measures should be taken to prevent further inputs.

2.5 Towards enforceable measures for microplastics in soils

Authors: Annegret Biegel-Engler, Katrin Scholz, Tatjana Schneckenburger

Affiliations: German Environment Agency

Abstract: Science is increasingly concerned with the impact of plastics on the soil ecosystem and the spread of microplastics in the environment. It is a fact that plastics remain in soils for a very long time. Today, it is difficult to deduce what risks particles and additives will pose to humans and the environment in the future. However, the uncertainties about the effects of microplastics should not prevent us from taking regulatory action. Thus, the entries of plastics into soils should be reduced to a minimum as a precautionary measure. This requires legal regulations. It is necessary, that these measures are controllable and enforceable. Therefore we need robust analytical methods and concrete procedures to reduce plastic levels, for example, in the production of compost. This presentation presents the challenges and possible solutions for legal regulations.

3 Poster session (titles only)

3.1 Material- and size-dependent effects of submicron and nanoplastics after oral uptake in vitro

Authors: Maxi Paul, Mariam Salim, Marwin-Dirk Wälisch, Albert Braeuning, Holger Sieg

Affiliations: German Federal Institute for Risk Assessment (BfR)

3.2 Microplastics in soil induce a new microbial habitat, with consequences for bulk soil microbiomes

Authors: Susanne Kublik[1], Silvia Gschwendtner[1], Tobias Magritsch[1], Viviane Radl[1], Matthias C. Rillig[2], Michael Schloter[1,3]

Affiliations: [1] : Helmholtz Zentrum München; [2] : Freie Universität Berlin; [3] : Technische Universität München

3.3 Challenges of sample preparation and analysis of standard sand and sediment samples in an interlaboratory comparism test – a participant's approach

Authors: Bence PRIKLER[1,2]* Gábor BORDÓS[2] Zoltán PALOTAI[2], Edit KASZAB[1], Rózsa SEBŐK[1,2], Sándor SZOBOSZLAY[1]

Affiliations: [1] : Hungarian University of Agriculture and Life Sciences; [2] : WESSLING Hungary Kft.

3.4 Influence of dissolved organic matter in the transport of microplastics in soil

Authors: Federico M. Ivanic[1,2], Georg Guggenberger[2], Jannis F. Carstens[1,3]

Affiliations: [1] : Institute of Environmental Research and Engineering, UNSAM; [2] : Institute of Soil Science, Leibniz Universität; [3] : Technische Universität Clausthal

3.5 impact of microplastic types on landfill soils in regard of geochemical cycles and potential pathogenic bacteria (title not specified)

Authors: Stephan Rohrbach et al.

Affiliations: Universität Hannover

3.6 First indicative analysis of WWTP sludge samples in Hungary and its analytical challenges

Authors: Gabor Bordos, Bence Prikler, Zoltan Palotai

Affiliations: WESSLING Hungary Ltd

3.7 Determination of microplastics in Moss: Challenges and first result

Authors: Carmen Wolf, Mike Wenzel et al.

Affiliations: Institut für Energie- und Umwelttechnik (IUTA) e.V.

3.8 Transport of microplastics in agricultural soils - Analyzing surface water runoff as an environmental pathway

Authors: Saunak Sinha Ray, Tomas Dostal, David Zumr

Affiliations: Czech Technical University in Prague

Imprint

Publisher

Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
buergerservice@uba.de
Internet: www.umweltbundesamt.de
/umweltbundesamt.de
/umweltbundesamt

Completion: October/2022

Authors, Institutions

Hannes Schritt
Ecologic Institut
Pfalzburger Straße 43/44
10717 Berlin
Hannes.schritt@ecologic.eu