Universität Stuttgart
Institut für Biomaterialien und biomolekulare Systeme (IBBS)
Forschungseinheit Biodiversität & wissenschaftliches Tauchen

MIKROPLASTIK IN DER UMWELT

Zusammenfassung des Forschungsstandes

Prof. (apl.) Dr. Franz Brümmer

Persönliche Erklärung & Hinweise

- Außerplanmäßiger Professur an der Universität Stuttgart mit der Lehrbefugnis für Zoologie & Biophysik
- Am Institut für Biomaterialien und biomolekulare Systeme (IBBS) der Fakultät 4
- Leiter der eigenständigen Forschungseinheit Biodiversität & Wissenschaftliches Tauchen
- Eigene Forschungsarbeiten zum Thema Mikroplastik (u. a. auch Drittmittelprojekte)
- Lehre in den Studiengängen Technische Biologie, Umweltschutztechnik & Medizintechnik
- Ehrenamtliche Tätigkeiten gem. LNTVO
- Ehrenamtliches Engagement beim LSV BW (Komm. Sport & Umwelt) und beim DOSB (Umweltkomm., Ag Mikroplastik im Sport) und Vorsitzender des Kuratoriums Sport & Natur

- Informationen in diesem Vortrag nach bestem Wissen und Gewissen zusammengestellt
- Vortrag enthält persönliche Schwerpunkte und eigene Interpretationen
- Den Standards guter wissenschaftlicher Praxis der DFG verpflichtet
- Einschränkungen hinsichtlich Aktualität und Vollständigkeit
- Keinerlei privaten kommerziellen Interessen

Inhalte

- Einleitung
- Definition(en) Mikroplastik
- Quellen & Vorkommen von Mikroplastik
- Qualitätskriterien bei Untersuchungen zu Mikroplastik
- Ergebnisse & Erkenntnisse
- Fazit

Kunststoffe in der Umwelt – PlasticAge

Faszination und Schrecken eines Materials in Kunst und Wissenschaft

Plastikgranulat am Strand
Rotes Meer, Ägypten (2013)

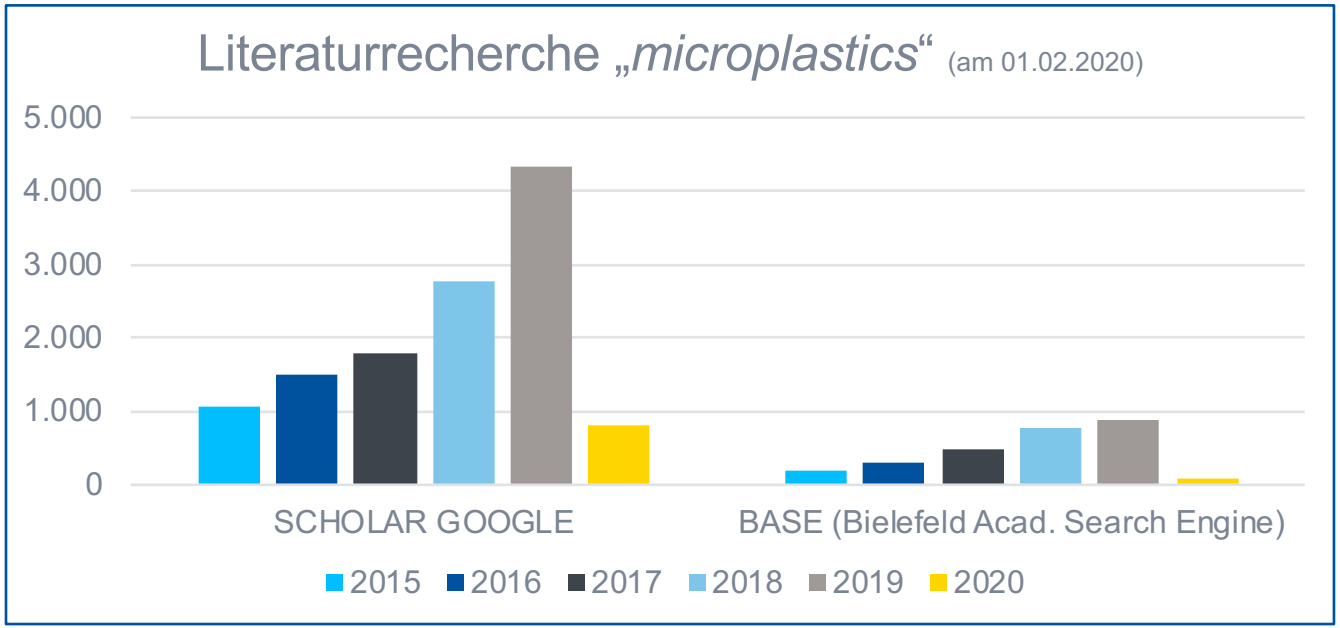
11.02.2014 WILHELMA Stuttgart

Eisbär Anton starb an Fremdkörpern

In der Nacht auf Montag ist in der Wilhelma der Eisbär Anton gestorben. Todesursache war ein Fremdkörper. Gefunden wurden Teile einer verschluckten Jacke oder auch Tasche, die einem Besucher vermutlich aus Unachtsamkeit ins Gehege gefallen war. Anton wurde 25 Jahre alt.

Lorenz
X-Cut
Lorenz

Relevanz Mikroplastik in der wissenschaftlichen Literatur



SCHOLAR Google:

- Suche „über Alles“

BASE:

- Suche nur im Text
- ohne reine Zitate, Patente, usw.

Mikroplastik in der Umwelt – na und!?

RISIKO!?

Potenzielles Risiko

für die Umwelt (Organismen & Lebensräume)

für die Gesundheit des Menschen

Kleine bis kleinste Polymer-basierte Partikel

überall, „verfügbar“ für die (orale & zelluläre) Aufnahme

Transport innerhalb der Nahrungsnetze

Vektoren für Chemikalien

Vektoren für (pathogene) Mikroorganismen (Biofilme)

sehr stabil und sehr lange haltbar

„zerfallen“ in immer kleinere Partikel

praktisch nicht mehr zurückholbar wenn einmal in der Umwelt

Was ist Mikroplastik?

- **NOAA Marine Debris Division (2009)**

– microplastics as plastic particles smaller than 5mm.

– no requirement for a “lower bound” in size,

– practical matter (neuston nets): beween 5mm and 333µm

- **ECHA Restriction Report – Microplastics (2019)**

– ‘microplastic’ means a material consisting of solid polymer-containing particles, to which additives or other substances may have been added,

– and where ≥ 1% w/w of particles have

– all dimensions 1nm ≤x≤ 5mm

– for fibres, a length of 3nm ≤x≤ 15mm and length to diameter ratio of >3.

Environmental Science & Technology

Feature

Cite This: Environ. Sci. Technol. 2019, 53, 1039−1047

pubs.acs.org/est

Are We Speaking the Same Language? Recommendations for a Definition and Categorization Framework for Plastic Debris

Nanna B. Hartmann,[*,†] Thorsten Hüffer,[*,‡] Richard C. Thompson,[§] Martin Hassellöv,[∥] Anja Verschoor,[⊥] Anders E. Daugaard,[#] Sinja Rist,[†] Therese Karlsson,[∥] Nicole Brennholt,[¶] Matthew Cole,[▽] Maria P. Herrling,[○] Maren C. Hess,[◆] Natalia P. Ivleva,[◇] Amy L. Lusher,[▲] and Martin Wagner[*,▼]

ABSTRACT: The accumulation of plastic litter in natural environments is a global issue. Concerns over potential negative impacts on the economy, wildlife, and human health provide strong incentives for improving the sustainable use of plastics. Despite the many voices raised on the issue, we lack a consensus on how to define and categorize plastic debris. This is evident for microplastics, where inconsistent size classes are used and where the materials to be included are under debate. While this is inherent in an emerging research field, an ambiguous terminology results in confusion and miscommunication that may compromise progress in research and mitigation measures. Therefore, we need to be explicit on what exactly we consider plastic debris. Thus, we critically discuss the advantages and disadvantages of a unified terminology, propose a definition and categorization framework, and highlight areas of uncertainty. Going beyond size classes, our framework includes physicochemical properties (polymer composition, solid state, solubility) as defining criteria and size, shape, color, and origin as classifiers for categorization. Acknowledging the rapid evolution of our knowledge on plastic pollution, our framework will promote consensus building within the scientific and regulatory community based on a solid scientific foundation.

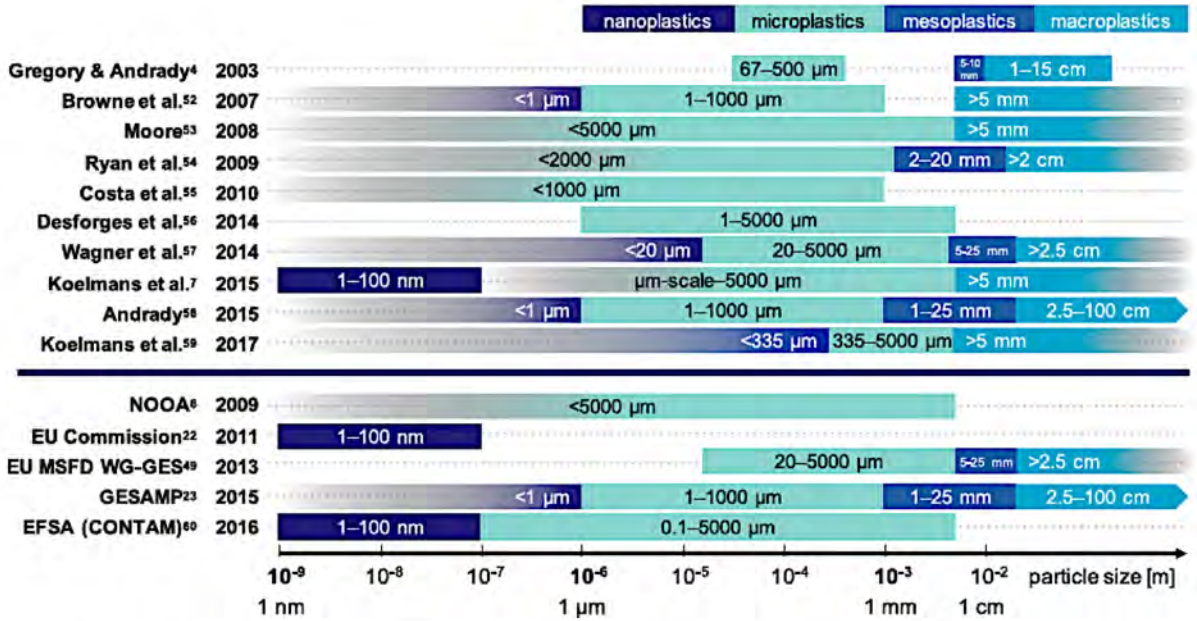


Figure 1. Examples of differences in the categorization of plastic debris according to size as applied (and/or defined) in scientific literature and in institutional reports. It should be noted that this does not represent an exhaustive overview of all used size classes.

aus: Hartmann et al. (2019)

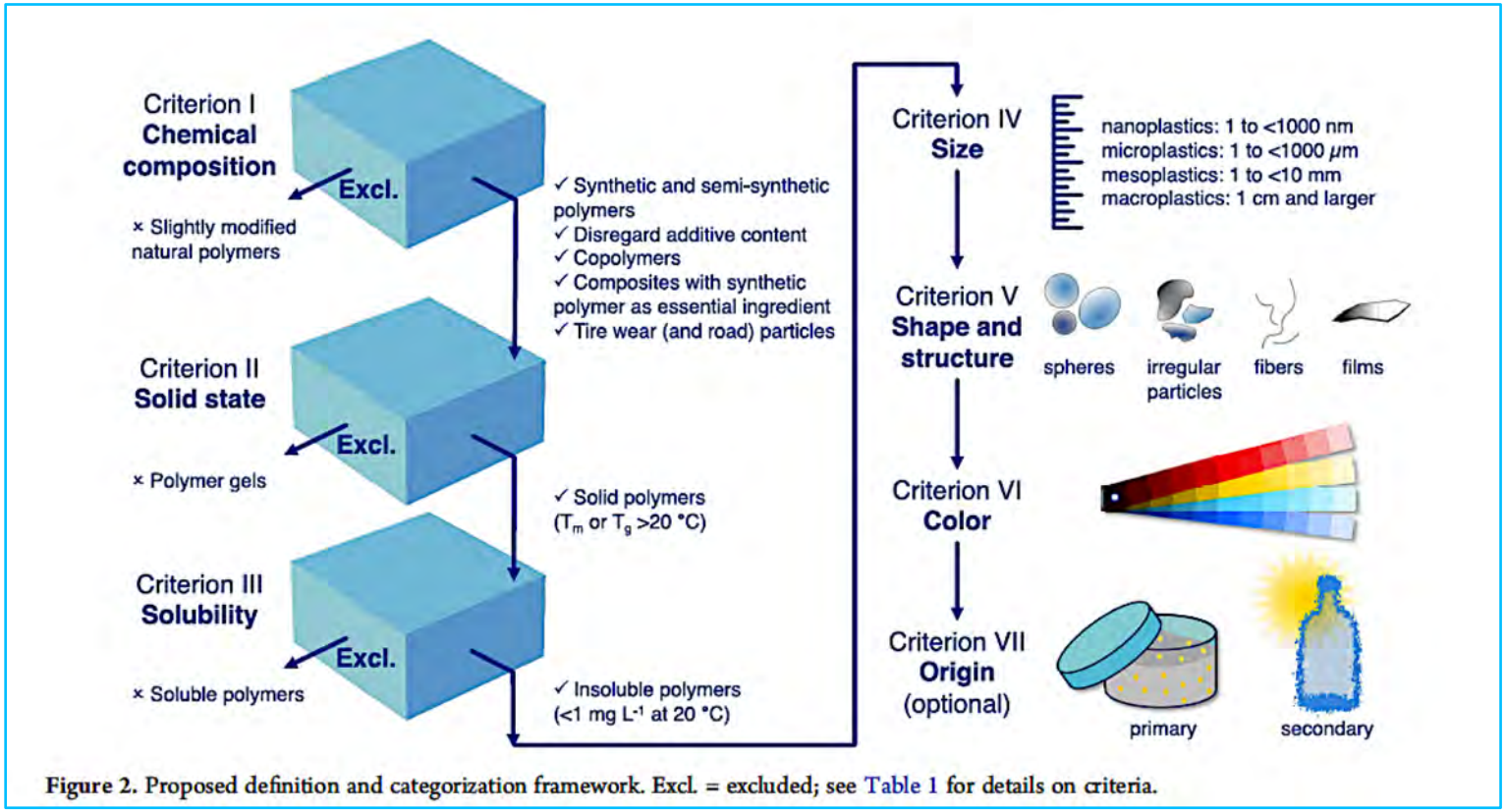
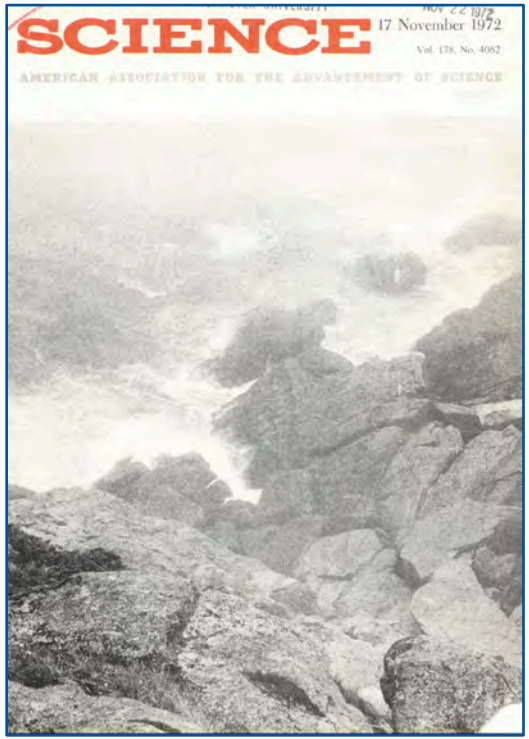


Figure 2. Proposed definition and categorization framework. Excl. = excluded; see Table 1 for details on criteria.

aus: Hartmann et al. (2019)

Mikroplastik in der Umwelt...



Plastics on the Sargasso Sea Surface

Abstract. *Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.*

Polystyrene Spherules in Coastal Waters

Abstract. *Polystyrene spherules averaging 0.5 millimeter in diameter (range 0.1 to 2 millimeters) are abundant in the coastal waters of southern New England. Two types are present, a crystalline (clear) form and a white, opaque form with pigmentation resulting from a diene rubber. The spherules have bacteria on their surfaces and contain polychlorinated biphenyls, apparently absorbed from ambient seawater, in a concentration of 5 parts per million. White, opaque spherules are selectively consumed by 8 species of fish out of 14 species examined, and a chaetognath. Ingestion of the plastic may lead to intestinal blockage in smaller fish.*

Carpenter E.J. et al. 1972 SCIENCE 175 & 178

Mikroplastik in der Umwelt - Ozeane

Wie viel Kunststoff ist im Meer?

- **250.000 t**
- **> 5 Trillionen Kunststoffteile**

Wie viel Kunststoff gelangt jährlich ins Meer?

(von 275 Mio. Tonnen)

- **4,8 – 12,7 Mio. t (2010)**
- Tendenz: steigend!
  - **2015: 9,1 Mio. t**
  - **2025: ca. 20 Mio. t**

PLOS ONE 2014

RESEARCH ARTICLE

Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea

Marcus Eriksen[1*], Laurent C. M. Lebreton[2], Henry S. Carson[3,4], Martin Thiel[5,6,7], Charles J. Moore[8], Jose C. Borerro[9], Francois Galgani[10], Peter G. Ryan[11], Julia Reisser[12]

1. Five Gyres Institute, Los Angeles, California, United States of America, 2. Dumpark Data Science, Wellington, New Zealand, 3. Marine Science Department, University of Hawaii at Hilo, Hilo, Hawaii, United States of America, 4. Washington Department of Fish and Wildlife, Olympia, Washington, United States of America, 5. Facultad Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile, 6. Millennium Nucleus Ecology and Sustainable Management of Oceanic Island (ESMOI), Coquimbo, Chile, 7. Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Coquimbo, Chile, 8. Algalita Marine Research and Education, Long Beach, California, United States of America, 9. eCoast Limited, Raglan, New Zealand, 10. Departement Océanographie et Dynamique des Ecosystemes, Institut français de recherche pour l'exploitation de la mer (Ifremer), Bastia, Corsica, France, 11. Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch, South Africa, 12. School of Environmental Systems Engineering and Oceans Institute, University of Western Australia, Crawley, Perth, Australia

*marcus@5gyres.org

OPEN ACCESS

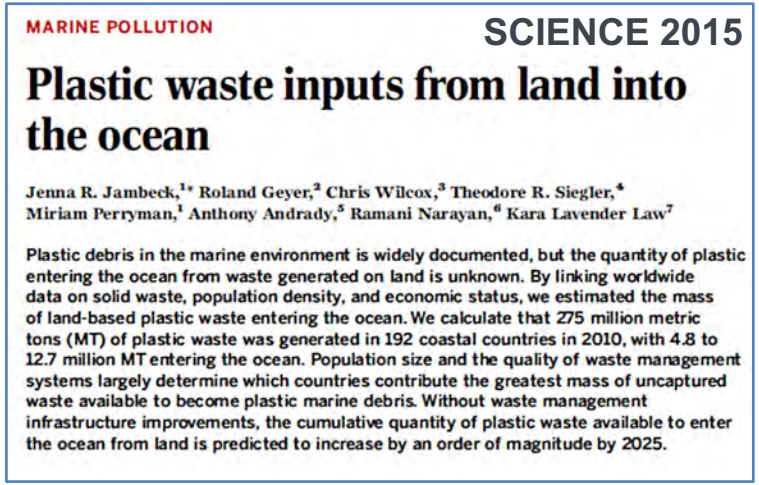
Citation: Eriksen M, Lebreton LCM, Carson HS, Thiel M, Moore CJ, et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. PLoS ONE 9(12): e111913. doi:10.1371/journal.pone.0111913

Editor: Hans G. Dam, University of Connecticut, United States of America

Received: May 6, 2014

Accepted: October 2, 2014

Published: December 10, 2014



MARINE POLLUTION

SCIENCE 2015

Plastic waste inputs from land into the ocean

Jenna R. Jambeck,[1*] Roland Geyer,[2] Chris Wilcox,[3] Theodore R. Siegler,[4] Miriam Perryman,[1] Anthony Andrady,[5] Ramani Narayan,[6] Kara Lavender Law[7]

Plastic debris in the marine environment is widely documented, but the quantity of plastic entering the ocean from waste generated on land is unknown. By linking worldwide data on solid waste, population density, and economic status, we estimated the mass of land-based plastic waste entering the ocean. We calculate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean. Population size and the quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become plastic marine debris. Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025.

Mikroplastik in der Umwelt – Flüsse & Seen

Bestandsaufnahme in Schweizer Gewässern

- Genfer See, Bodensee, Neuenburgersee, Lago Maggiore, Zürichsee, Brienzersee, Rhone
- Kunststoffpartikel zwischen 0,3 und 5 mm
- **Wasser:**
  - 27 Proben mit im Mittel **0,1 Mikroplastik-Partikel/m²**
  - 7 Proben ohne Belastung
- **Sand:**
  - 21 Proben mit im Mittel **1.000 Mikroplastik-Partikel/m²**
  - 12 Proben ohne Belastung
- Vorwiegend Polypropylen (PP), Polyethylen (PE), Schaumstoffe

Flussverschmutzung

Mehr Plastik als Fischlarven in der Donau

In der Donau schwimmt einer Studie zufolge viel mehr Müll als bisher angenommen. Die Plastikpartikel sind eine erhebliche Gefahr für die Tiere. (Die Zeit, 2014)

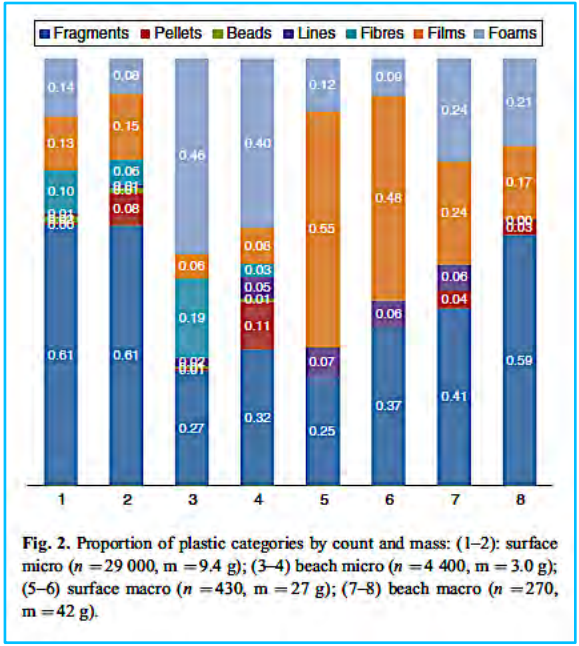
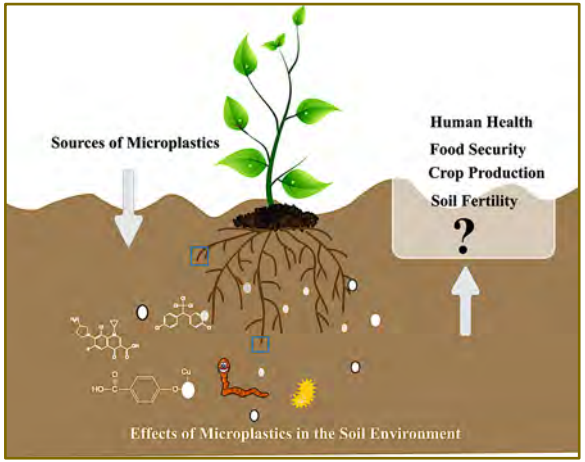


Fig. 2. Proportion of plastic categories by count and mass: (1–2): surface micro (n = 29 000, m = 9.4 g); (3–4) beach micro (n = 4 400, m = 3.0 g); (5–6) surface macro (n = 430, m = 27 g); (7–8) beach macro (n = 270, m = 42 g).

Faure et al., 2015

Mikroplastik in der Umwelt – Boden & Luft



Wang et al., 2019

- **Boden** (z. B. über Kompost)

  Weithmann et al. (2018): Organic fertilizer as a vehicle for the entry of microplastic into the environment. Sci Adv 4: eaap8060

- **Luft**

  Allen et al. (2019): Atmospheric transport and deposition of microplastics in a remote mountain catchment. NATURE Geoscience 12: 339-344.

  Klein & Fischer (2019): Microplastic abundance in atmospheric deposition within the Metropolitan area of Hamburg, Germany. Science of theTotal Environm. 685: 96-103.

Mikroplastik in der Umwelt – „Quell-Studien“

Tabelle 7: Tabellarische Darstellung der Quellen von primären und sekundären Mikropartikeln aus Kunststoff in Deutschland (Quelle: Eigene Darstellung)

Quellen von Mikropartikeln aus Kunststoff in Deutschland	Quantifizierung der Quellen in Tonnen Mikropartikel pro Jahr
Primäre Mikropartikel	
▪ Kosmetische Produkte	500
▪ Wasch-, Reinigungs- und Pflegemittel im Gewerbe und der Industrie	< 100
▪ Strahlmittel zum Entgraten von Oberflächen	< 100
▪ Mikronisierte Kunststoffwachse in technischen Anwendungen	100.000
Sekundäre Mikropartikel	
▪ Fragmentierung von Kunststoffabfällen	unbekannt
▪ Synthetische Chemiefasern aus Kleidungsstücken und sonstigen Textilien	80 bis 400
▪ Verlust von Pellets in der Herstellung und Weiterverarbeitung von Kunststoffen	21.000 bis 210.000
▪ Reifenabrieb	60.000 bis 111.000

Mikroplastik in der Umwelt – „Quell-Studien“

Kunststoffemissionen in D:

Makroplastik

116.000 t/a bzw. **1.405 g/(cap a)**

Mikroplastik

333.000 t/a bzw. **4.000 g/(cap a)**

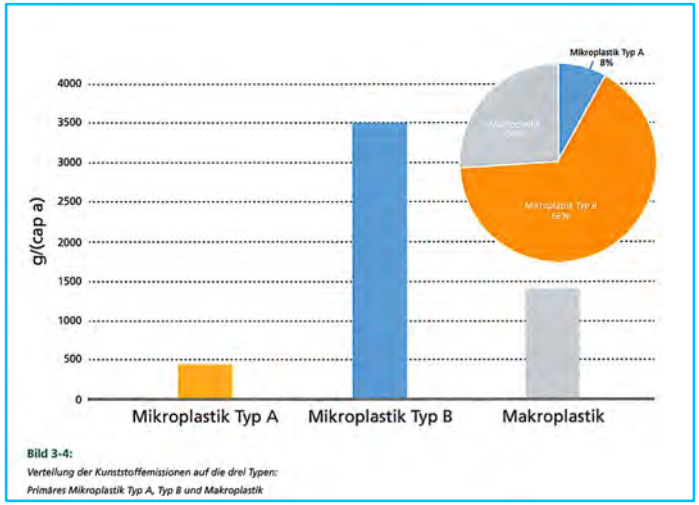
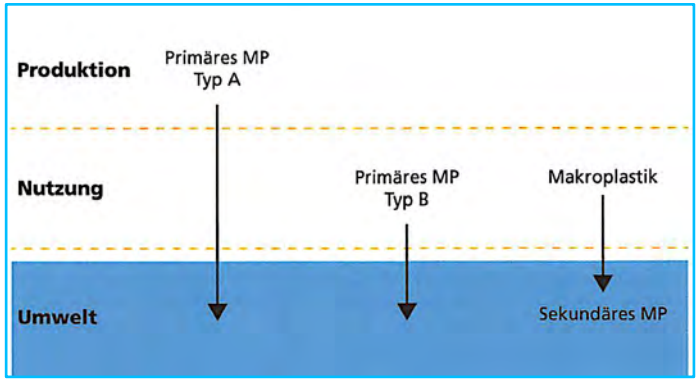


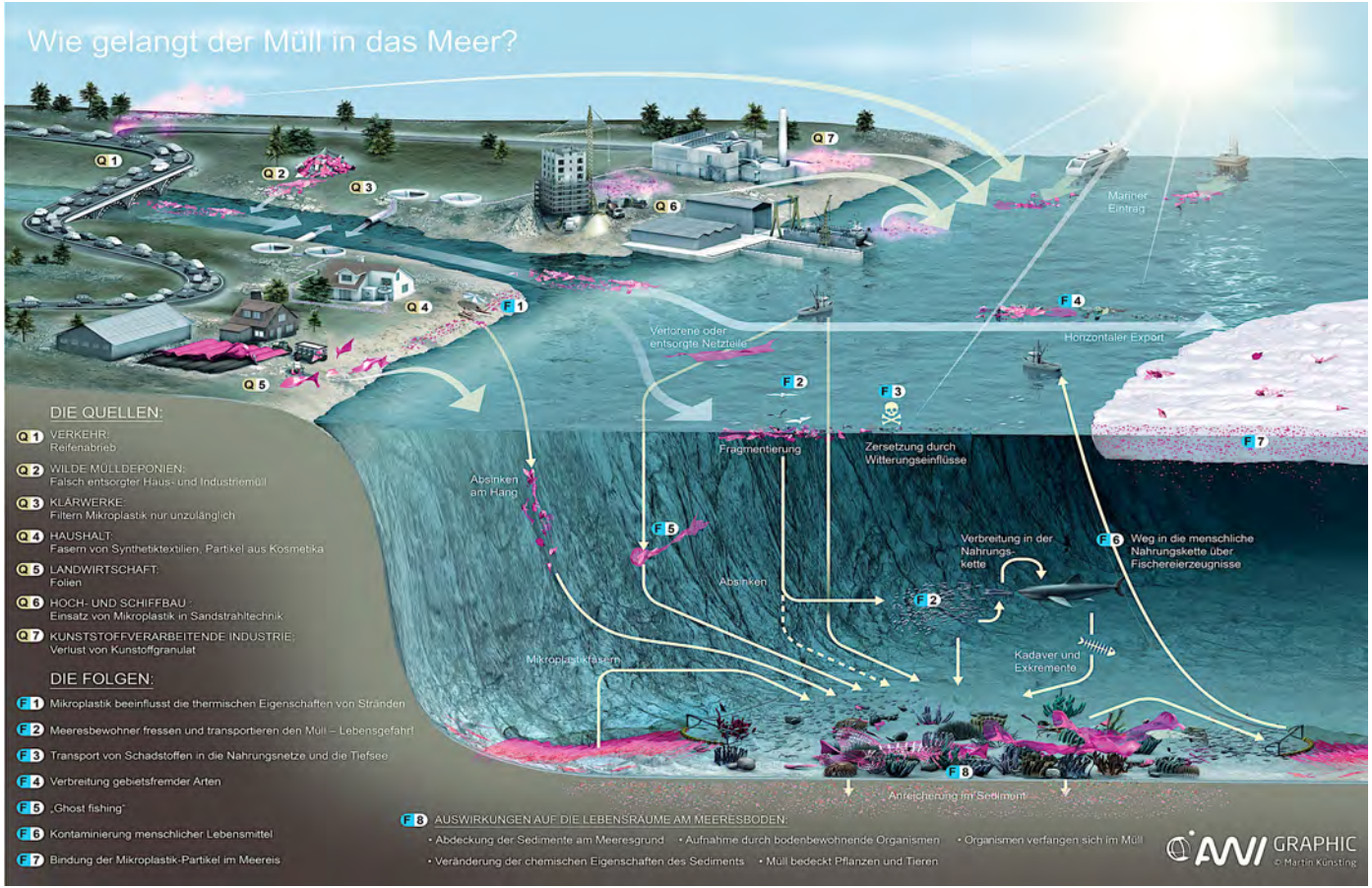
Bild 3-4:
Verteilung der Kunststoffemissionen auf die drei Typen: Primäres Mikroplastik Typ A, Typ B und Makroplastik



Bertling et al. UMSICHT, 2018

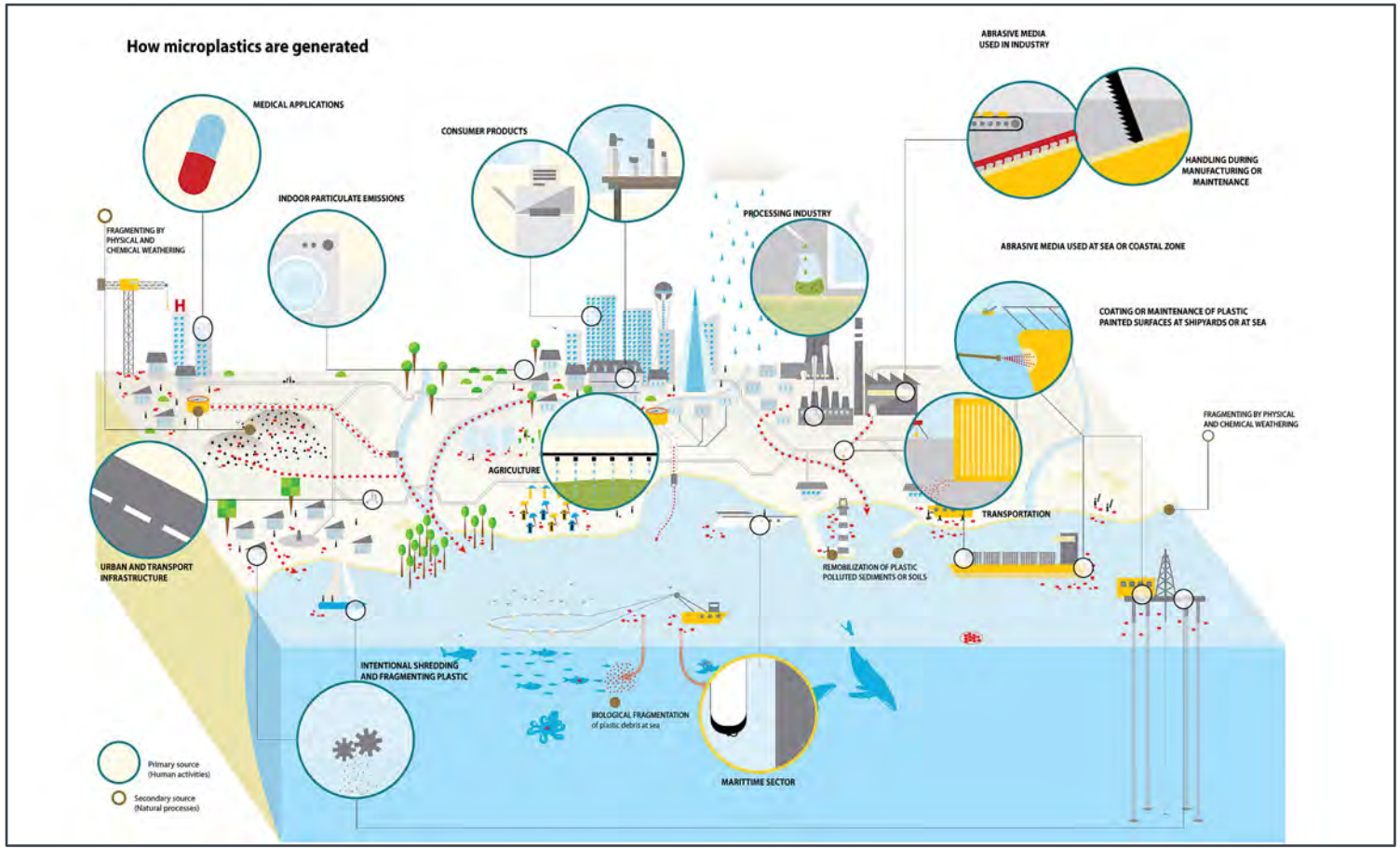
Mikroplastik in der Umwelt – „Quell-Studien“

Mikroplastik in der Umwelt – „Quellen & Verteilungspfade“



https://orangeocean.org

Mikroplastik in der Umwelt – „Quellen & Verteilungspfade“



UN Environm. Program
Marine Litter Vital Graphics
Maphoto/Riccardo Pravettoni

Mikroplastik in der Umwelt – „MP cycling in the ecosystems“

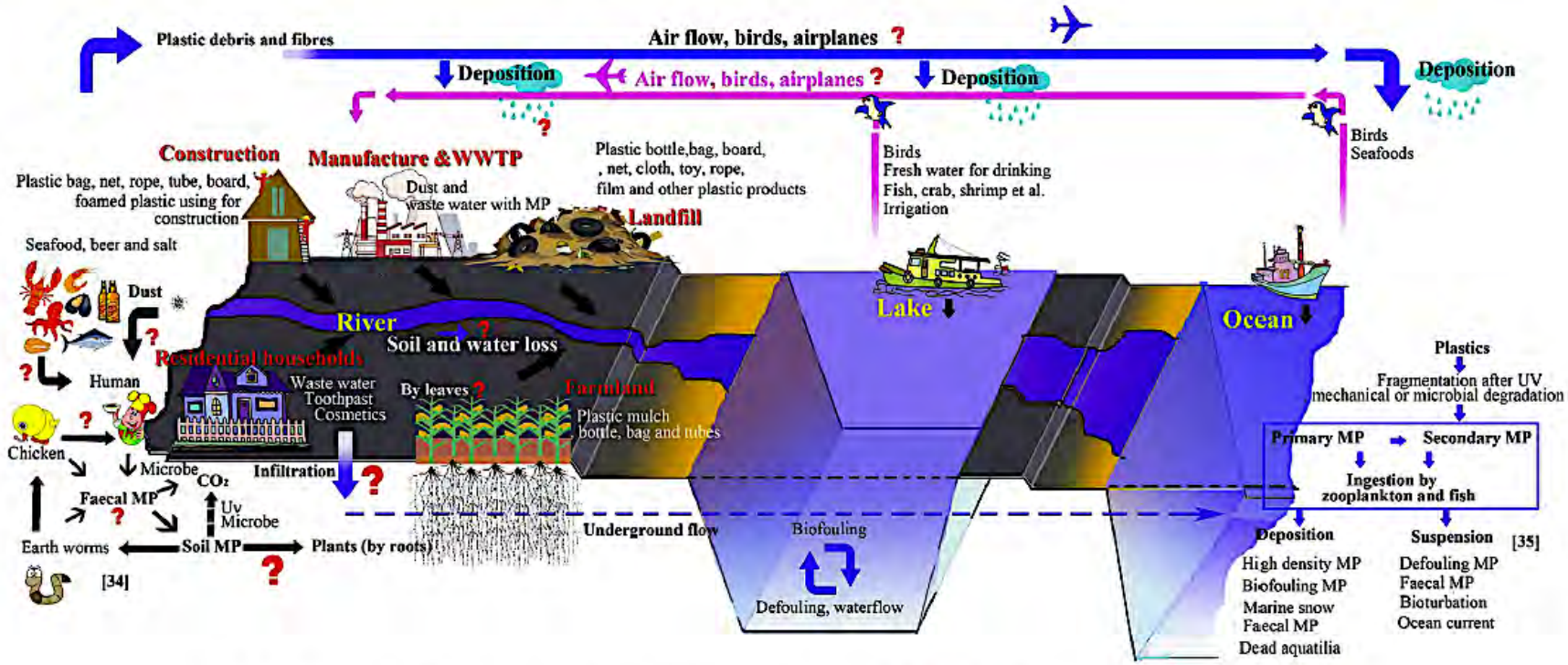
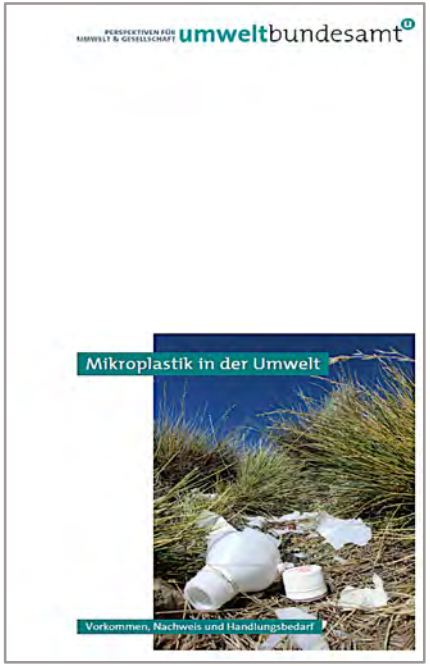
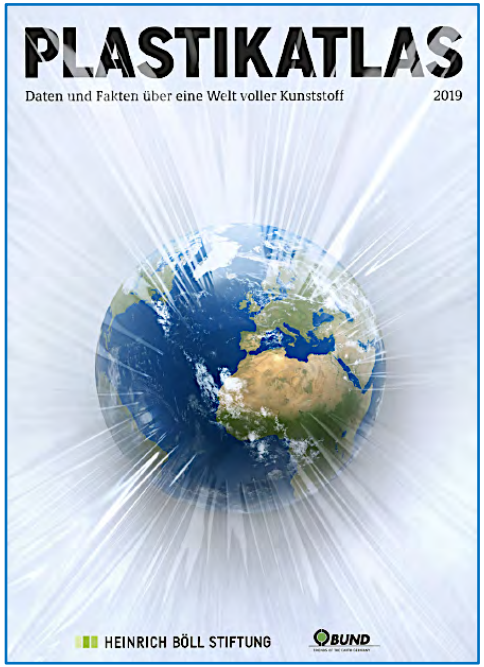


Fig. 1. MP cycling in the ecosystems (Part of terrestrial ecosystem refers to Ref. [34], and part of marine ecosystem refers [35]).





UNIVERSITÄT HOHENHEIM
UNIVERSITÄT BAYREUTH
Universität Stuttgart
Fraunhofer IGT

MIKOBO

Mikrokunststoffe in Komposten und Gärprodukten aus Bioabfallverwertungsanlagen und deren Eintrag in Böden
Erfassen, Bewerten, Vermeiden

Baden-Württemberg

BSI Bundesverband der Deutschen Sportartikel-Industrie e.V.

TextileMission

Eine Initiative des Bundesministeriums für Bildung und Forschung

Plastik in der Umwelt

Quellen • Senken • Lösungsansätze

Ein Mensch nimmt pro Woche durchschnittlich bis zu fünf Gramm Plastik auf. Das entspricht in etwa dem Gewicht einer Kreditkarte.

WWF

Plastik im Meer

Die größte Müllkippe der Welt ist gut versteckt

Plastikinseln, größer als viele Länder, sollen im Meer treiben. Ein falsches Bild. Es ist schlimmer: Unser Plastikmüll ist überall, selbst in der Tiefsee und der Arktis.

Von **Maria Mast** und **Sven Stockrahm**

20. August 2018, 10:42 Uhr | 339 Kommentare

ZEIT ONLINE

Plastik im Honig: Test zeigt Verschmutzung im Naturprodukt

Mikroplastik auch im menschlichen Stuhl nachgewiesen

Forscher aus Österreich haben im menschlichem Stuhl nach Mikroplastik gesucht – und sind fündig geworden. Was das für die menschliche Gesundheit bedeutet, ist noch unklar.

23.10.2018, 05:30 Uhr

Neue Zürcher Zeitung

So macht unsere Kleidung die Meere kaputt

UTOPIA

13. November 2016 von Annika Flatley Kategorien: Konsum

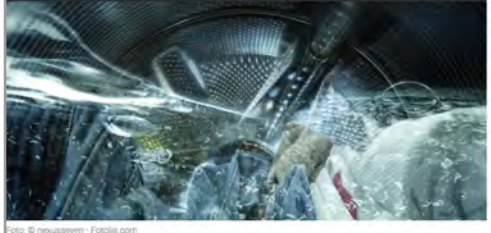


Foto: © nexusseven - Fotolia.com

Vom Fleecepulli bis zum Cocktailkleid – bei jeder Wäsche lösen sich aus unserer Kleidung hunderttausende winzige Fasern. Eine wissenschaftliche Studie bestätigt jetzt: Unsere Kleidung trägt so wesentlich zur Verseuchung der Meere mit Kunststoffpartikeln bei.

Umweltschutz

05.04.2018, 09:52 Uhr

Komposterde ist voller Mikroplastik

DER TAGESSPIEGEL

Über den Biomüll aus Haushalten und Gewerben kommen winzige Kunststoffteilchen in die Umwelt. Das Problem ist laut einer Studie groß. VON ROLAND KNAUER

Megaproblem Mikroplastik: Plastiktüten, Flaschen und sonstige erkennbare Fremdkörper können aus dem Biomüll entfernt werden, wenn... FOTO: IMAGO/RUPERT OBERHÄUSER

Mikroplastik in der Umwelt & mögliche Wirkungen – Studiendesign

Liebezeit, G. & E. Liebezeit (2013): Non-pollen particulates in **honey** and sugar. Food Additives & Contaminants: Part A: 30(12): 2136-2140.

Mühlschlegel, P; Hauk. A.; Walter, U. and Sieber R. (2017): Lack of evidence for microplastic contamination in honey. Food Additives and & Contaminants: Part A, DOI:10.1080/19440049.2017.1347281.

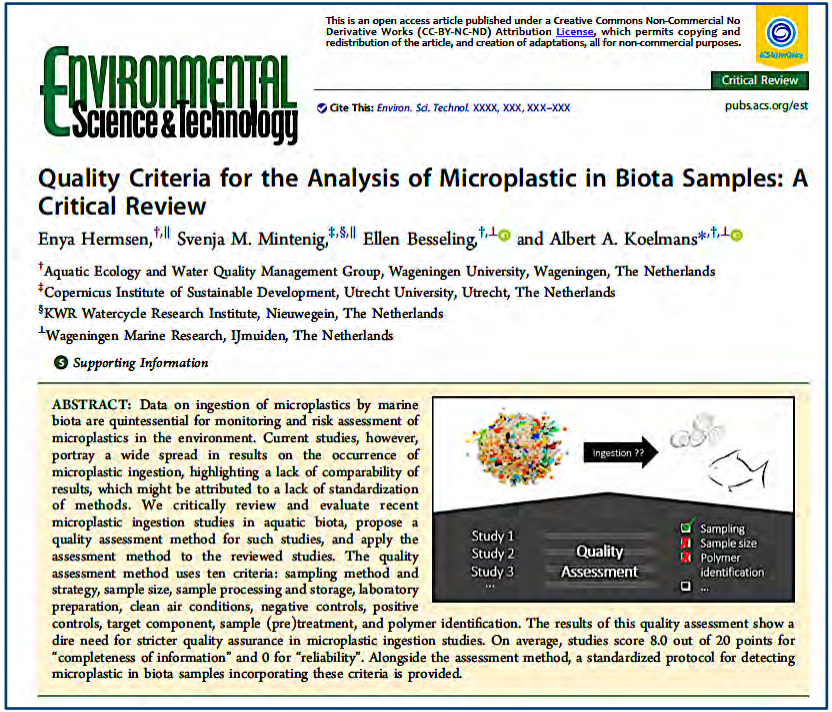
Liebezeit, G. & E. Liebezeit (2014): Synthetic particles as contaminants in German **beers**. Food Additives & Contaminants: Part A: 31(9): p. 1574-1578.

Lachenmeier, D.W., et al. (2015): Microplastic identification in German beer - an artefact of laboratory contamination? Deutsche Lebensmittel Rundschau, 111. Jahrgang: 437-440.

Mikroplastik in Honig und Bier

Mikroplastik in der Umwelt und Wirkungen – Studiendesign

- Qualitätskriterien?!
- Critical Reviews!
  - **10 Kriterien (für Ingestionsstudien)**
  - **(aber nicht ausreichend!)**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Environmental Science & Technology
Critical Review
Cite This: Environ. Sci. Technol. XXXX, XXX, XXX−XXX
pubs.acs.org/est

Quality Criteria for the Analysis of Microplastic in Biota Samples: A Critical Review

Enya Hermsen,[†,∥] Svenja M. Mintenig,[‡,§,∥] Ellen Besseling,[†,⊥] and Albert A. Koelmans*[,†,⊥]

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[‡]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands
[§]KWR Watercycle Research Institute, Nieuwegein, The Netherlands
[⊥]Wageningen Marine Research, IJmuiden, The Netherlands

Supporting Information

ABSTRACT: Data on ingestion of microplastics by marine biota are quintessential for monitoring and risk assessment of microplastics in the environment. Current studies, however, portray a wide spread in results on the occurrence of microplastic ingestion, highlighting a lack of comparability of results, which might be attributed to a lack of standardization of methods. We critically review and evaluate recent microplastic ingestion studies in aquatic biota, propose a quality assessment method for such studies, and apply the assessment method to the reviewed studies. The quality assessment method uses ten criteria: sampling method and strategy, sample size, sample processing and storage, laboratory preparation, clean air conditions, negative controls, positive controls, target component, sample (pre)treatment, and polymer identification. The results of this quality assessment show a dire need for stricter quality assurance in microplastic ingestion studies. On average, studies score 8.0 out of 20 points for "completeness of information" and 0 for "reliability". Alongside the assessment method, a standardized protocol for detecting microplastic in biota samples incorporating these criteria is provided.

Mikroplastik in der Umwelt und Wirkungen – Studiendesign

(1) Beprobungsmethodik

(2) Beprobungsstelle

(3) Probenaufarbeitung & Probenlagerung

(4) Präparation im Labor

(5) Laborbedingungen

(6) Negativ-Kontrolle

(7) Positiv-Kontrolle

(8) Zielorgan(e)

(9) Probebehandlung

(10) Polymeridentifizierung

aus: Hermsen et al., 2018

Table 2. Standardized Protocol for the Detection of Ingested Microplastic in (Marine) Biota

1. Sampling methods	Sampling characteristics that should be recorded: - Gear - Mesh size and mesh size at cod-end (if applicable) - Material - Location - Depth - Date and time of day - Presence of plastic materials
2. Sample size	A suitable sample size of 50 individuals per research unit (species, food web, ecoregion, feeding type, etc.) is required.[42,45] The confidence interval of the ingestion incidences should be reported (Figure 1).
3. Sample processing and storage	Between the moment of capture and the examination in the lab the biota samples should be stored on ice or frozen at −20 °C. Smaller organisms can also be preserved in a glass container with ethanol or formaldehyde. Any sample handling, such as dissections, should be left for the lab.
4. Laboratory preparation	All materials, equipment, and laboratory surfaces need to be thoroughly washed and rinsed; afterward, all materials should be kept under clean air conditions. Used solutions and filters should be checked before use; the same applies for the outside of the sample specimens.[6]
5. Clean air conditions	The handling of samples should be performed in clean air facilities.[28] Samples should not be taken out of the clean air facilities without being sealed off. If sampling processing and analysis cannot fully be conducted under clean air conditions, the implementation of negative controls (see criterion 6) will get even more important.
6. Negative control	A replicate of 3 negative controls is advised that are included for each batch of samples and treated in parallel to the sample treatment.[42] Additionally, if the samples have to be analyzed outside of the clean air facilities, clean Petri dishes should be placed next to the sample, and checked for any occurred air- borne contamination.
7. Positive controls	A replicate of 3 is advised in which microplastics of known polymer identity and of targeted sizes are added to "clean" samples, which are then treated and analyzed the same way as the actual samples. The particle recoveries are calculated by tallying the numbers of retrieved particles to the amounts added.
8. Target component	To ensure monitoring all ingested microplastic, the full gastrointestinal tract (esophagus to vent) of fish and the entire body of smaller species, e.g. bivalves, should be examined.
9. Sample treatment	A digestion step must be included to dissolve organic matter in the sample when aiming in the detection of small microplastics (<300 μm). The digestion method described by Foekema et al. (2013)[6] using a 10% KOH solution and enzymatic digestion methods (yet only for small organisms) are most suitable.[49,61,65] In any case, heating or drying of the samples at high temperatures should be avoided.
10. Polymer identification	Until now, most common methods in the field of microplastic research are FTIR or Raman spectroscopy, pyrolysis or TGA- GC-MS. The polymer identification is required for all, or at least a subsample of particles: When numbers of pre- sorted particles are <100, all particles should be analyzed. For particle numbers >100, >50% should be identified with a minimum of 100 particles. Particle counts with confidence intervals, detection limits for the count and for minimum particle size, polymer types and percentages (of different polymer types, of synthetic vs natural material), and particle sizes should be reported.

Mikroplastik in der Umwelt und Wirkungen – Studiendesign

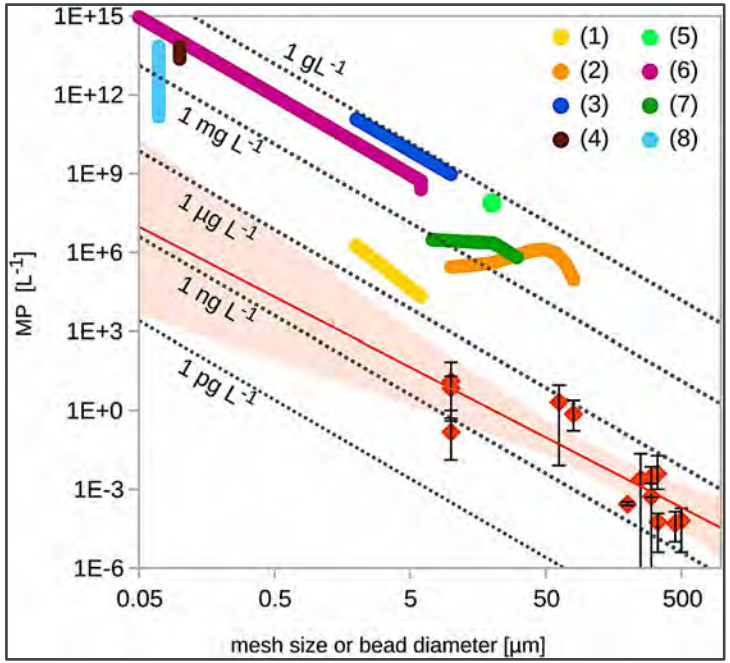
(1) Beprobungsmethodik
(2) Beprobungsstelle
(3) Probenaufarbeitung & Probenlagerung
(4) Präparation im Labor
(5) Laborbedingungen
(6) Negativ-Kontrolle
(7) Positiv-Kontrolle
(8) Zielorgan(e)
(9) Probebehandlung
(10) Polymeridentifizierung

Hermsen et al., 2018

(11) Mikroplastik-Konzentration
(12) Partikelgröße
(13) …

Hermsen et al., 2018:

- pro Kriterium 2 Punkte
- max. 20 Punkte
- 35 Publikationen bewertet
- Durchschnitt 8 Punkte
- max. 15 Punkte



Microplastic exposure studies should be environmentally realistic
R. Lenz, K. Enders and T. G. Nielsen
PNAS July 19, 2016 113 (29) E4121-E4122;

Mikroplastik in der Umwelt & Wirkungen – PUBLIKATIONEN

- **Qualitätskriterien**
  - 12 Kriterien + X (angepasst an Fragestellung!)
- **Reliability**
  - Verlässlichkeit, Vertauenswürdigkeit, Relevanz, Bedeutung
  - Klimisch et al. (1997)
- **Review Papers**
- **Critical Reviews**
- **Interpretationen**

REGULATORY TOXICOLOGY AND PHARMACOLOGY 25, 1–5 (1997)
ARTICLE NO. RT961076

A Systematic Approach for Evaluating the Quality of Experimental Toxicological and Ecotoxicological Data[1]

H.-J. KLIMISCH,[2] M. ANDREAE, AND U. TILLMANN
BASF Aktiengesellschaft, D-67056 Ludwigshafen, Germany

Reliability

Code	Category
1	Reliable without restriction
2	Reliable with restrictions
3	Not reliable
4	Not assignable

- Reporting effects in organisms related to microplastic exposure
- Being the most highly cited articles
- Being consistently mentioned in review articles

KLIMISCH, H. J., ANDREAE, M. & TILLMANN, U. (1997):
A Systematic Approach for Evaluating the Quality of Experimental Toxicological and Ecotoxicological Data.
Regulatory Toxicol. & Pharmacol.:25, 1-5.

1* = *reliable without restrictions: *"studies or data [...] generated according to generally valid and/or internationally accepted testing guidelines (preferably performed according to GLP) or in which the test parameters documented are based on a specific (national) testing guideline [...] or in which all parameters described are closely related/comparable to a guideline method."*

2* = *reliable with restrictions: *"studies or data [...] (mostly not performed according to GLP), in which the test parameters documented do not totally comply with the specific testing guideline, but are sufficient to accept the data or in which investigations are described which cannot be subsumed under a testing guideline, but which are nevertheless well documented and scientifically acceptable."*

3* = *not reliable: "studies or data [...] *in which there were interferences between the measuring system and the test substance or in which organisms/test systems were used which are not relevant in relation to the exposure (e.g. unphysiological pathways of application) or which were carried out or generated according to a method which is not acceptable, the documentation of which is not sufficient for assessment and which is not convincing for an expert judgment."*

4* = *not assignable: *"studies or data [...] which do not give sufficient experimental details and which are only listed in short abstracts or secondary literature (books, reviews, etc.)."*

ECHA (2019): Annex to the Annex XV restriction report intentionally added microplastics. VERS. 1.2 / 22 Aug. 2019

Mikroplastik in der Umwelt & Wirkungen – PUBLIKATIONEN

- Mikroplastik im Trinkwasser
- Flüße, Seen, Quellen, Grund-wasser, Hahnenwasser, Mineralwasser in Flaschen

- 50 Studien näher betrachtet
- 9 Kriterien festgelegt
- max. 18 Punkte
- Durchschnitt: 8,41 Punkte
- Maximal: 15 Punkte
- von 2 Studien

Water Research 155 (2019) 410–422

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Review

Microplastics in freshwaters and drinking water: Critical review and assessment of data quality

Albert A. Koelmans [a, *], Nur Hazimah Mohamed Nor [a], Enya Hermsen [a], Merel Kooi [a], Svenja M. Mintenig [b, c], Jennifer De France [d, **]

However, only four out of 50 studies received positive scores for all proposed quality criteria, implying there is a significant need to improve quality assurance of microplastic sampling and analysis in water samples.

Mikroplastik in der Umwelt – Wirkungen auf Organismen & Ökosysteme

- Besseling, E. et al. (2014) ‘Nanoplastic affects growth of S. obliquus and reproduction of D. magna’, Environmental Science and Technology, 48(20), pp. 12336–12343. doi: 10.1021/es503001d.
- Huerta Lwanga, E. et al. (2016) ‘Microplastics in the Terrestrial Ecosystem: Implications for Lumbricus terrestris (Oligochaeta, Lumbricidae)’, Environmental Science and Technology, 50(5), pp. 2685–2691.
- Oliveira, M. et al. (2013) ‘Single and combined effects of microplastics and pyrene on juveniles (0+ group) of the common goby Pomatoschistus microps (Teleostei, Gobiidae)’, Ecological Indicators. Elsevier, 34, pp. 641–647. doi: 10.1016/j.ecolind.2013.06.019.
- Rehse, S., Kloas, W. and Zarfl, C. (2016) ‘Short-term exposure with high concentrations of pristine microplastic particles leads to immobilisation of Daphnia magna’, Chemosphere, 153, pp. 91–99.
- Triebskorn R, Braunbeck T, Grummt T, Hnaslik L, Huppertsberg S, Jekel M, Knepper TP, Krais S, Müller YK, Pittroff M, Ruhl AS, Schmieg H, Schür C, Strobel C, Wagner M, Zumbülte and Köhler HR (2019) Relevance of nano- and microplastics for freshwater ecosystems: A critical review. Trends in Analytical Chemistry 110: 375-392.

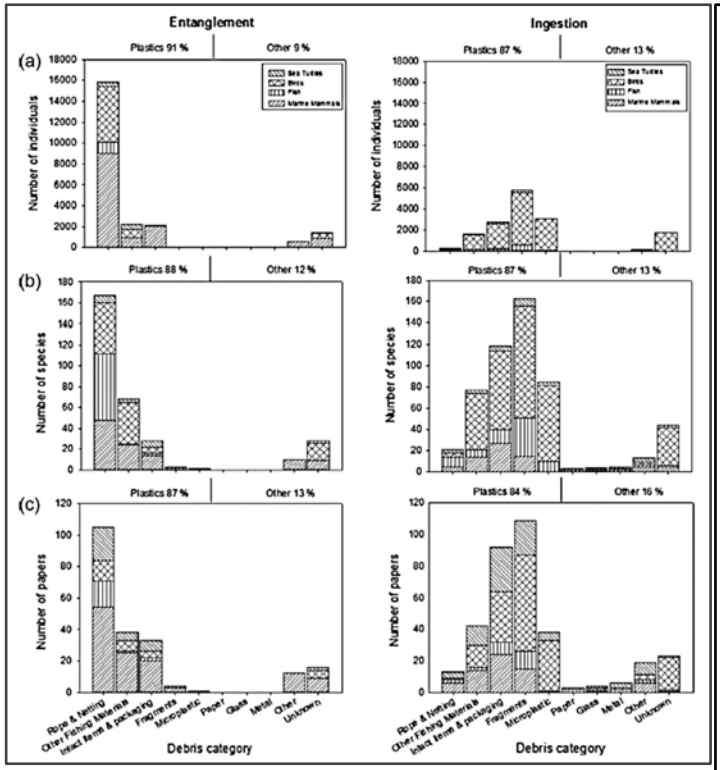
Mikroplastik in der Umwelt - Auswirkungen auf Arten & -vielfalt

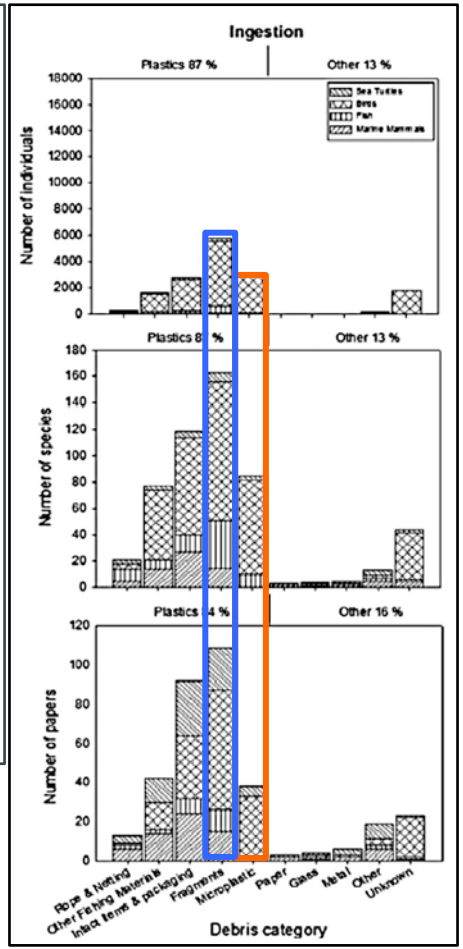
MARIN

Gall & Thompson (2015): The impact of debris on marine life. Marine Pollution Bulletin 92:170-179.

- Müll (Gesamtmeeresmüll) betrifft **693 Arten**
- Davon ca. **90 %** betroffen durch Plastikmüll: 637 Arten
- 17 % (108) der betroffenen Arten sind **gefährdete Arten**
- Zusammenfassung von 340 Veröffentlichungen

	Verfangen in		**Aufnahme von**	
	Kunststoff	Anderer Müll	Kunststoff	Anderer Müll
Betroffene Individuen (in %)	91	9	87	13
Betroffene Arten (in %)	88	12	87	13





Aufnahme von Mikroplastik betrifft:

- 85 Arten
- 3.000 Individuen

Veröffentlichungen: 40

Aufnahme von Fragmenten betrifft:

- 160 Arten
- 6.000 Individuen

Veröffentlichungen: 110

Mikroplastik in der Umwelt - Auswirkungen auf Arten & -vielfalt

MARIN

Organismus	Kunststoff	Effekt	Literatur

Wale und andere marine Säugetiere	Allgemein, große Teile wie Netze bis Mikroplastik	• Verfangen
		  • Ertrinken
		  • Strangulation
		  • Einschnüren/Abschnüren durch Wachstum
		• Primäre/direkte Aufnahme:
		  • innere Verletzungen, Blockade Verdauungstrakt
		  • erhöhte Werte bei PCBs, PBDEs
		• Sekundäre Aufnahme (Plankton)
		  • positive Korrelation mit Krebs, Immuno-Suppression, Veränderungen des endokrinen Systems
			Balch & Perry 2012
			Chowra 2013

Daphnia magna (Wasserfloh / Krebstiere)	Nano Polystyrol	Daphnia:
		• Reduzierte Körpergröße
		• Veränderungen in der Reproduktion
		  • Anzahl und Körpergröße der Neugeborenen geringer
		  • Zunahme von Missbildungen (68 %) ab Konzentrationen von 30 mg NanoPS / L
		  • Anreicherungen im Panzer mit gleicher Farbe wie NanoPS
			Besseling et al 2014

Tölpel Albatrosse Andere Seevögel	Diverse	Nestbau mit Kunststoffmaterial → Einschnürungen, vor allem bei Küken Füttern Küken mit Kunststoff Von Kunststoff abgeleitete Verbindungen im Gewebe → Bioakkumulation	Chowra 2013 Vegter et al 2014
Meeresschildkröten	Diverse	Aufnahme → Verhungern Auch bioabbaubare Tüten zersetzten sich nicht schnell genug (bei Pflanzenfressern etwas schneller)	Chrowra 2013 Müller et al 2011
Reptilien	Diverse	Mikro-Plastik beeinflusst Eigenschaften von Sand z.B. Temperatur → verändert temperaturabhängige Geschlechterverteilung	Vegter et al 2014

Mikroplastik in der Umwelt - Auswirkungen auf Arten & -vielfalt

MARIN

Organismus	Kunststoff	Effekt	Literatur
Scenedesmus obliquus (Alge)	Nano Polystyrol	• Reduziertes Populationswachstum • Reduzierte Chlorophyllkonzentration • Weniger CO2-Aufnahme • Vermehrte Bildung reaktiver Sauerstoffspezies	Besseling et al 2014
Mytilus edulis (Miesmuschel)	HDPE – High-Density Polyethylen Polystyrol	• Aufnahme der Partikel • Histologische Veränderungen, Entzündungsreaktion • Größerer Energiebedarf	Moos et al (2012) Cauwenberghe et al (2015)
Arenicola marina (Wattwurm)	Allg. Belastung des Meers Polystyrol	• Aufnahme der Partikel • Größerer Energiebedarf	Cauwenberghe et al (2015)
Lebensraum	**Kunststoff**	**Effekt**	**Literatur**
Mangroven	Diverse	Bedeckt und zerdrückt Sprosse	Chowra 2013
Korallenriffe	Diverse	Ersticken, Beschattung, Abrasion Große Stücke bieten neue Oberflächen für invasive Arten	Chowra 2013 Vegter et al 2014

Mikroplastik in der Umwelt - Auswirkungen auf Arten & -vielfalt

LIMNISCH

- Unterschiedliche Kunststoffe
- Unterschiedliche Größen und Konzentrationen
- Vereinzelt auch mehrere Kunststoffe gleichzeitig
- Verschiedene Endpunkte

- Meist negative Wirkungen

Organismen		Fokus
Fische	*Danio rerio*	Stoffwechsel Mortalität
Crustacea	*Daphnia* sp. *Gammarus* sp.	Immobilisierung Reproduktion
Mollusca	*Corbicula f.* *Dreissena p.*	Nahrungsaufnahme Mortalität
Annelida	*Lumbricus* sp.	Wachstum, Reproduktion
Cnidaria	*Hydra attenuata*	Nahrungsaufnahme, Reproduktion
Chironomida	*Chironomus* sp.	Mortalität, Emergenz
Algen	*Scenedesmus* sp. *Chlorella* sp.	Wachstum, Photosynthese
Bakterien	*Vibrio fisheri*	Biolumineszenz

Mikroplastik in der Umwelt - Auswirkungen auf Arten & -vielfalt

LIMNISCH

SCIENTIFIC REPORTS

OPEN

Plastic waste interferes with chemical communication in aquatic ecosystems

Received: 27 September 2018
Accepted: 31 January 2019
Published online: 10 April 2019

B. Trotter, A. F. R. M. Ramsperger, P. Raab, J. Haberstroh & C. Laforsch

Environmental pollution with plastic waste has gained increasing attention, as the contamination of aquatic habitats poses a challenge to these ecosystems. Plastic waste has direct negative effects on animals such as reduced growth rate, fecundity or life span. However, the indirect effects of plastic waste, which has the ability to sorb chemicals from the surrounding media, on chemical communication have yet to be investigated. Chemical communication is crucial for aquatic organisms, e.g., to avoid predation. The planktonic water flea *Daphnia* (Crustacea), an important link between trophic levels, relies on info-chemicals (kairomones) to assess its current predation risk and to form inducible defences. We show that plastic waste, composed of high-density polyethylene (HDPE) and polyethylene terephthalate (PET) interferes with the formation of inducible defences in *Daphnia longicephala* when exposed to a combination of kairomones of *Notonecta glauca* and plastic waste. *D. longicephala* shows a reduction in all defensive traits, including body length, crest width and time until primiparity, compared to exposure to solely kairomone conditioned media. Plastic waste in the absence of kairomones had no effect on defensive traits. Since it is vital to adjust these defences to the current predation risk, any misperception can have far-reaching ecological consequences. Therefore, plastic waste can have indirect effects on organisms, which may manifest at the community level.

Mikroplastik in der Umwelt - Auswirkungen auf die Artenvielfalt

LIMNISCH

SCIENCE ADVANCES | RESEARCH ARTICLE

Sci. Adv. (2020): 6 : eaay4054 / 31 January 2020

ECOLOGY

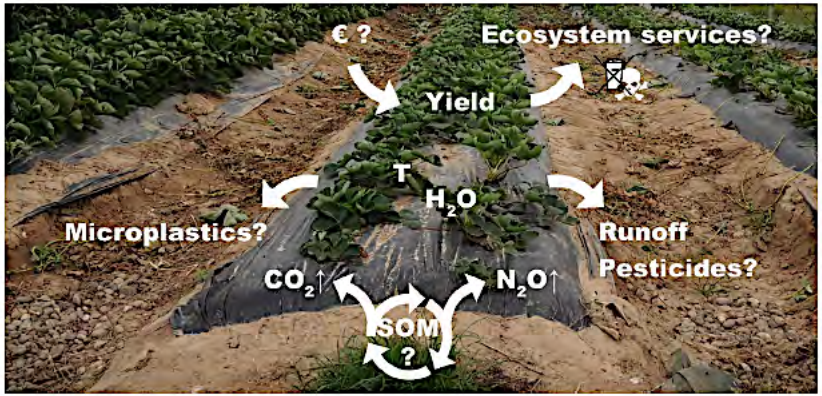
Nano- and microplastics affect the composition of freshwater benthic communities in the long term

P. E. Redondo-Hasselerharm[1]*, G. Gort[2], E. T. H. M. Peeters[1], A. A. Koelmans[1]

Given the societal concern about the presence of nano- and microplastics in the environment, our nescience with respect to in situ effects is disturbing. Data on long-term implications under ecologically realistic conditions are particularly important for the risk assessment of nano- and microplastics. Here, we evaluate the long-term (up to 15 months) effects of five concentrations of nano- and microplastics on the natural recolonization of sediments by a macroinvertebrate community. Effects were assessed on the community composition, population sizes and species diversity. Nano- and microplastics adversely affected the abundance of macroinvertebrates after 15 months, which was caused by a reduction in the number of Naididae at the highest concentration (5% plastic per sediment dry weight). For some other taxa, smaller but still significant positive effects were found over time, altogether demonstrating that nano- and microplastics affected the community composition.

Mikroplastik in der Umwelt - Auswirkungen auf die Artenvielfalt

TERRESTRISCH



Steinmetz et al. (2016):
Plastic mulching in agriculture. Trading short-term agronomic benefits for long-term soil degradation? Review
Science of the Total Environment 550: 690–705.

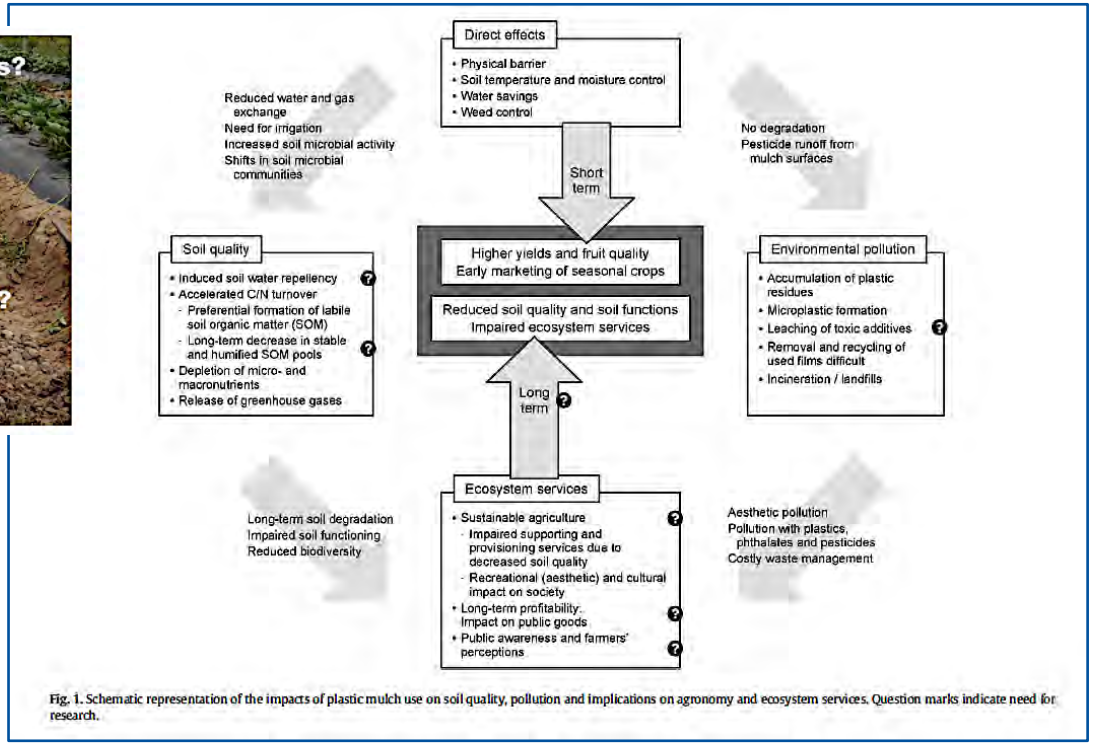


Fig. 1. Schematic representation of the impacts of plastic mulch use on soil quality, pollution and implications on agronomy and ecosystem services. Question marks indicate need for research.

aus: Steinmetz et al. (2016)

Mikroplastik in der Umwelt – Vorkommen & Auswirkungen

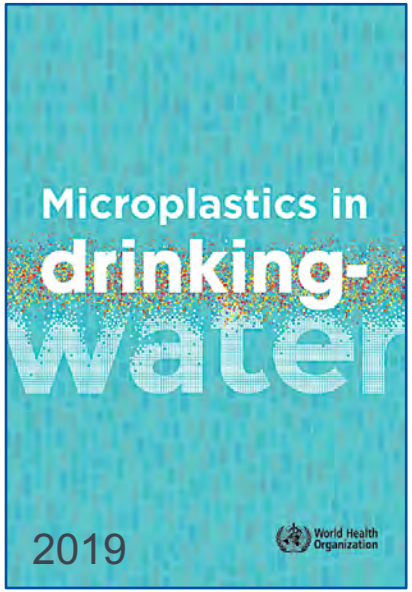
IN LEBENSMITTEL

Trinkwasser

- Mikroplastik
- 10^4 Partikel/L
- Mikroplastik als Vektor
- Chemikalien & Additive
- Biofilme

Muscheln, Fisch

Speisesalz



www.bfr.bund.de

Water Research 129 (2018) 154–162

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Analysis of microplastics in water by micro-Raman spectroscopy: Release of plastic particles from different packaging into mineral water

Darena Schymanski [a, b], Christophe Goldbeck [a], Hans-Ulrich Humpf [b], Peter Fürst [a, *]

Water Research 141 (2018) 307–316

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Small-sized microplastics and pigmented particles in bottled mineral water

Barbara E. Oßmann [a, b, *], George Sarau [c, d], Heinrich Holtmannspötter [a, 1], Monika Pischetsrieder [b], Silke H. Christiansen [c, d, e], Wilhelm Dicke [a, **]

Mikroplastik in Trinkwasser

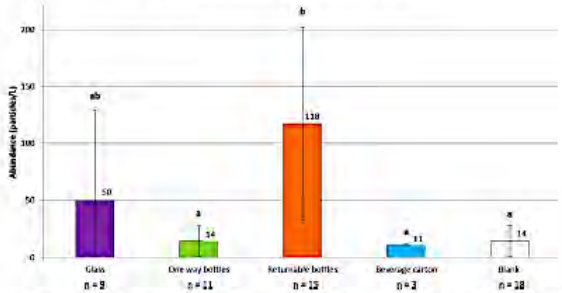
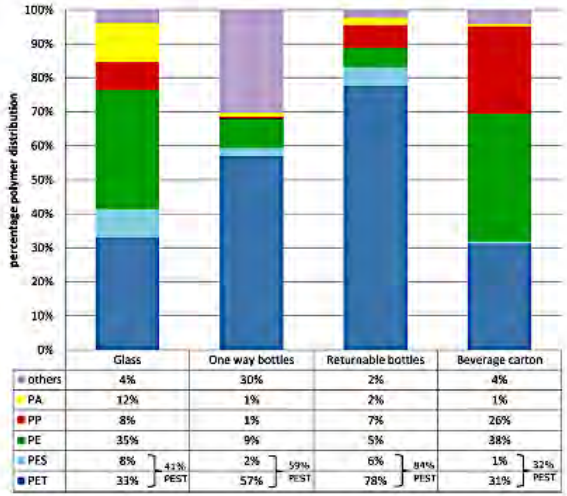


Fig. 3. Mean microplastic content of water from different packaging. Different letters above the error bars indicate significant difference; same letters indicate no significant difference ($p < 0.05$). Error bars represent ± 1 standard deviation.



	Glass	One way bottles	Returnable bottles	Beverage carton
others	4%	30%	2%	4%
PA	12%	1%	2%	1%
PP	8%	1%	7%	26%
PE	35%	9%	5%	38%
PES	8%	2%	6%	1%
PET	33%	57%	78%	31%
PES + PET	41%	59%	84%	32%

Fig. 4. Polymer distribution of the microparticles found in water from different packaging types (for abbreviations of polymer type see Table 1).

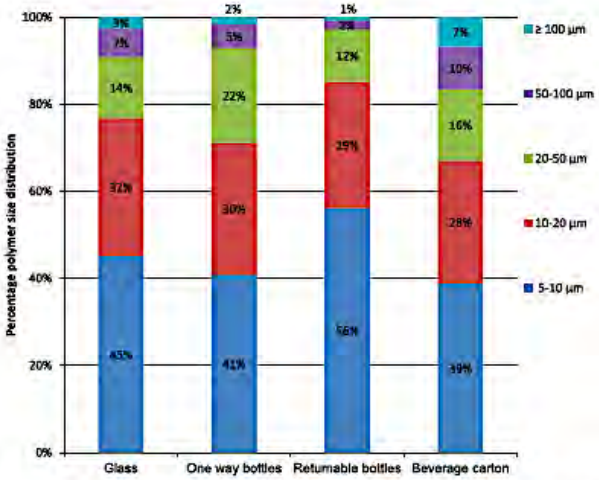


Fig. 6. Polymer size distribution of the microparticles found in water from different packaging types. Particles were classified into 5 size ranges: 5–10 µm, 10–20 µm, 20–50 µm, 50–100 µm and ≥100 µm.

aus: Schymanski et al., 2018

Mikroplastik in der Umwelt – ein Fazit

- **Methodik**
  - Mikroplastik definiert (7 Kriterien)
  - Untersuchungsmethodik vorhanden (teilweise zu optimieren!)
  - Qualitätskriterien für Studiendesign
- **Publikationslage**
  - Jede Menge Veröffentlichungen
  - Zahlreiche Publikationen unzureichend
  - Gute bis sehr gute Veröffentlichungen(Critical Reviews, Reviews)
  - Teilweise nur erste Abschätzungen
  - Weitere Forschungen werden benötigt

Mikroplastik in der Umwelt – ein Fazit

- **Erkenntnisse & Ergebnisse**
  - Mikroplastik kommt überall in nennenswerten Mengen vor
  - (Aus-)Wirkungen für alle untersuchten Biota*
    - Vertebraten, Invertebraten, Protisten, Bakterien
    - Unterschiedlichste Wirkungen (Stoffwechsel, Reproduktion, Mortalität, u.v.m)
  - (Aus-)Wirkungen für untersuchte Lebensgemeinschaften & Ökosysteme
    - Marine & limnische Biozönosen, Brackwasser
    - Wirkungen auf Ökosystemdienstleistungen (Verschlechterungsverbot)
    - EU WRRL, BBodSchG, Nat. Biodiversitätsstrategie
  - Mikroplastik in Lebensmittel - Lebensmittelsicherheit
    - Trinkwasser, Muscheln, Fische
    - schwierige (bis unmögliche) Risikobewertung

*Risikobewertung für Menschen wurde hier nicht berücksichtigt

Universität Stuttgart
IBBS

Biodiversität & wissenschaftliches Tauchen

Vielen Dank!

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The-sea-starts-here-dont-litter-initiative

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