

Disclaimer

'This is a copy of the accepted paper as submitted for publication. Readers are advised to refer to the final version of the paper which can be found at <https://pubs.acs.org/doi/10.1021/acs.est.8b05297>

Response to the Letter to the Editor Regarding Our Feature “Are We Speaking the Same Language? Recommendations for a Definition and Categorization Framework for Plastic Debris”

We welcome the comments by Stark¹ on our feature article² and the opportunity to discuss further certain aspects of how to define and categorize plastic debris. We especially appreciate this contribution because fostering a constructive debate was one goal of our work and is crucial to advance towards a consensus. Stark comments on 1) the size categorization and the consideration of other ongoing work, 2) a missing discussion on biodegradability as an additional criterion, and 3) the distinction between artificial and natural polymers.

Regarding 1), we welcome that the ISO working group agrees with our size classification. However, as their activities are ongoing and the outputs are not yet publicly available, we were not able to consider those in our article. With consensus building in progress, there will be some degree of agreement (as with ISO and others³) and disagreement.⁴

Regarding 2), we discussed the issue of biodegradability intensively within the group of authors and agreed to exclude it as a criterion for the following reasons: First, before a 'true' degradation (mineralization), biodegradable and conventional plastics alike will fragment to smaller particles.⁵⁻⁷ These would fulfill the criteria 1-3. Second, while biodegradation of a given material can be determined in laboratory tests, it is unclear whether this will predict the degradation of the inhomogeneous plastic mix in the environment. Third, every plastic item unintentionally found in the environment should classify as “plastic debris” notwithstanding whether it is made of biodegradable or non-biodegradable plastic. Hence, while we do agree that investigating the biodegradability of plastics is of utmost importance to understand their fate in the environment, we remain convinced that biodegradability should not be a criterion for a definition and categorization framework.

Regarding 3), Stark argues that regenerated cellulose is not semi-synthetic. In a larger context, this boils down to the question of how much a natural polymer needs to be modified to classify as “synthetic”. We have used the term according to its definition in Merriam Webster

“produced by chemical or biochemical synthesis; especially: *produced artificially*” (own highlight).⁸ Based on its artificial production from a natural polymer, we therefore consider regenerated cellulose “semi-synthetic”. This term may not be common in textile industry but is appropriate in an environmental context. We acknowledge the ambiguity of integrating regenerated celluloses under the umbrella of plastic debris. However, we are in favor of an inclusion as they are a significant part of marine litter, leach toxic chemicals, and generate nanoparticles as the case of cigarette butts highlights.^{9,10} In addition, we argued that a definition and categorization framework should not be tied to current analytical methods as these evolve constantly. To illustrate this, a recent study reports the ability to distinguish natural and semi-synthetic cellulose fibers by looking at one characteristic spectral band.¹¹

We are certain the discussion will not end here and very much welcome further debate on this topic.

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^{*,∇}

†Department of Environmental Engineering, Technical University of Denmark, Bygningstorvet B115, Kgs. Lyngby 2800, Denmark

‡Department of Environmental Geosciences, Environmental Science Research Network, and Research Platform Plastics in the Environment and Society (PLENTY), University of Vienna, Althanstrasse 14, Vienna 1090, Austria

§School of Biological and Marine Sciences, University of Plymouth, Plymouth PL4 8AA, United Kingdom

||Department of Marine Sciences, University of Gothenburg, Kristineberg 566, Fiskebackskil 45178, Sweden

⊥National Institute for Public Health and the Environment, Antonie van Leeuwenhoeklaan 9, Bilthoven 3721 MA, The Netherlands

#Department of Chemical and Biochemical Engineering, Danish Polymer Centre, Technical University of Denmark, Søtofts Plads B227, Kgs. Lyngby 2800, Denmark

¶Department Biochemistry and Ecotoxicology, Federal Institute of Hydrology, Am Mainzer Tor 1, Koblenz 56068, Germany

∇Marine Ecology & Biodiversity, Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth PL1 3DH, United Kingdom

○Ovivo Switzerland AG, Hauptstrasse 192, Aesch 4147, Switzerland

◆Department of Water Management and Water Protection, North Rhine Westphalia State Agency for Nature, Environment and Consumer Protection, Postfach 101052, Recklinghausen 45610, Germany

◇Institute of Hydrochemistry, Chair of Analytical Chemistry and Water Chemistry, Technical University of Munich, Marchioninstr. 17, Munich 81377, Germany

▲Norwegian Institute for Water Research (NIVA), Oslo 0349, Norway

▼Department of Biology, Norwegian University of Science and Technology (NTNU), Trondheim 7491, Norway

References

- (1) Stark, M., 2019. Letter to the Editor regarding 'Are we speaking the same language? Recommendations for a definition and categorization framework for plastic debris'. *Environ Sci Technol* **2019**, XXXX.
- (2) Hartmann, N. B.; Huffer, T.; Thompson, R. C.; Hasselov, M.; Verschoor, A.; Daugaard, A. E.; Rist, S.; Karlsson, T.; Brennholt, N.; Cole, M.; Herrling, M. P.; Hess, M. C.; Ivleva, N. P.; Lusher, A. L.; Wagner, M., Are We Speaking the Same Language? Recommendations for a Definition and Categorization Framework for Plastic Debris. *Environ Sci Technol* **2019**, 53, (3), 1039-1047.
- (3) Braun, U., Jekel, M., Gerdts, G., Ivleva, N., Reiber, J., **2018**, Microplastics Analytics - Sampling, Preparation and Detection Methods, Eds: Stein, U., Schmitt, H., Berlin.
- (4) GESAMP, **2019**. Guidelines on the monitoring and assessment of plastic litter and microplastics in the ocean (Eds: Kershaw P.J., Turra A., Galgani F.), (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 99.
- (5) Lambert, S.; Wagner, M., Formation of microscopic particles during the degradation of different polymers. *Chemosphere* **2016**, 161, 510-517.
- (6) Bagheri, A. R.; Laforsch, C.; Greiner, A.; Agarwal, S., Fate of So-Called Biodegradable Polymers in Seawater and Freshwater. *Global Challenges* **2017**, 1, (4).
- (7) Karlsson, T. M.; Hasselov, M.; Jakubowicz, I., Influence of thermooxidative degradation on the *in situ* fate of polyethylene in temperate coastal waters. *Mar Pollut Bull* **2018**, 135, 187-194.
- (8) <https://www.merriam-webster.com/dictionary/synthetic>, (last visited on April 10, 2019)
- (9) Chevalier, Q.; El Hadri, H.; Petitjean, P.; Bouhnik-Le Coz, M.; Reynaud, S.; Grassl, B.; Gigault, J., Nano-litter from cigarette butts: Environmental implications and urgent consideration. *Chemosphere* **2018**, 194, 125-130.
- (10) Slaughter, E.; Gersberg, R. M.; Watanabe, K.; Rudolph, J.; Stransky, C.; Novotny, T. E., Toxicity of cigarette butts, and their chemical components, to marine and freshwater fish. *Toxicol Control* **2011**, 20 Suppl 1, i25-9.
- (11) Cai, H.; Du, F.; Li, L.; Li, B.; Li, J.; Shi, H., A practical approach based on FT-IR spectroscopy for identification of semi-synthetic and natural celluloses in microplastic investigation. *Sci Total Environ* **2019**, 669, 692-701.