

Reply on RC2

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Author comment on "What comes after the Sun? On the integration of soil biogeochemical pre-weathering into microplastic experiments" by Frederick Büks and Martin Kaupenjohann, SOIL Discuss., <https://doi.org/10.5194/soil-2021-67-AC2>, 2022

Dear Referees.

Thank you very much for your mindful reviews and your very helpful comments. It has helped us to see some points which still need clarification. In the following, we want to explain how we propose to adjust our article based on the comments and also explain, why in some cases we do not agree with the proposed changes.

First – and most important – we deeply agree with the referees, that the manuscript contains different topics, that are

- already known (introduction, photochemical weathering of plastic)
- already reviewed (influence of MP on the soil fauna)
- or not widely researched (MP and soil structure, biogeochemical weathering)

and that the focus of this work should be on the latter, but by use of a shorter, more perspective-based manuscript type.

Our response is split into two parts: This first part contains a restructured manuscript in the format of a forum article with focus on soil biochemical weathering of microplastic surfaces and the possible need for soil-like pre-weathering of experimental microplastic. The second part (influence of microplastic on soil structure) will be re-submitted separately and is not part of this answer.

In the following you can find a list of all your points addressed (with numbers representing the order within the old document, excluded numbers no longer are part of the revised manuscript):

[5] Line 20-23: chemical reactions and physical processes are not clearly delineated; also, how do soil enzymes «weather» conventional plastics? The latter typically are chemically highly inert and it's not clear which enzymes can act on these materials

We tried to clarify this within the abstract and discuss it later within the main text.

[7] Line 37: maybe fragmentation is the better term than comminution?

done across the manuscript

[9] Line 80: Why were studies on biodegradable plastics excluded? Why were papers on polymer photooxidation excluded (by requiring that the term "soil" was included in the search).

We focused on the named non-biodegradable polymers that represent ...% of the plastic produced since the 1950s and their still growing legacy in soils. On the other hand, biodegradables are relatively new and only a small part of the plastic introduced into soils.

[14] Line 140: The wording makes it sound as if the plastic is either "juvenile" or aged. However, the juvenile plastic will age when in soils. Also, it seems that the terms polymer and plastic are not clearly defined and used. They are not the same.

That's correct. When juvenile plastic is added to the experimental soil it starts aging. However, in short-term experiments it is unlikely that even with the initial formation of biofilm cover there is an extended aging of surface characteristics. To focus in the process, we replaced "aged" by "aging" in some cases. After shortening the text, "polymers" and "plastic, however, are now used in the correct way without any text modifications.

[24] Line 253: smoothness must depend on how the microplastic is formed/generated. Are the authors therefore sure that the microplastic is always "smooth"?

We never had contrary impressions from REM/light microscopic images of juvenile commercial plastic items.

[25] Line 257: Chromophores are not "flaws". Also, there is indirect photolysis in which the polymers must not directly absorb light. Finally, most plastics that have exposure to sunlight are photostabilized. Photostabilizers slow down these reactions. This is not mentioned here.

Replaced by "weak bonds" and "indirect photolysis" added.

[26] Line 254: which of the conventional polymers contains NH groups?

deleted.

[27] Line 260: Carbonyls are uncharged

For soil environments, that's incorrect. Depending on the environmental pH, carbonyl groups (e.g. -COOH) are subject to (de-)protonation, which leads to variable charges. This is a process well known for soil organic matter and the soil mineral matrix strongly controlling adsorption of molecules and interaction with other particles in soil.

[29] Line 270: what are "biogeochemical attacks"? And moisture is also present during the use period of the plastic.

Replaced: "The plastic is now faced to new mechanical stresses such as (bio)turbation, largely moist conditions and exposed to a variety of biogeochemical processes."

[35] Line 339: Terms "decay" and "degradation" remain poorly defined. Aren't they describing the same overall loss of plastic integrity (either in terms of physical or chemical changes) / Line 384: the term "decomposition" is not defined. This is a general problem as the authors do not clearly define any of the terms. It seems that "weathering", decay, degradation, decomposition are all used interchangeably. Also, the term "biodegradation" is not defined

Both, decay and degradation describe the breakdown of organic matter by the soil (micro-)biome, while in other parts of the text the word was replaced by "aging", "depletion" or otherwise clarified.

[32] Line 340: "weight loss" is misleading. Because there is also Mw (molecular weight). The reviewer assumes the authors refer to mass loss?

Yes, thank you very much.

[37] Line 345: These polymers certainly decay. The authors mean that they don't biodegrade?

We instead used the term "biodegradation".

[38] Line 395: Why would one expect similar reactions? Photochemical reactions often trigger radical chemistry and needs light absorption and electron promotion to occur. This is not the case for subsurface reactions. So it seems very unlikely that the very different reactions result in the same products (unless, of course, the chemistry is looked at in a blunt manner, eg: increase in "oxygen" content)

That's exactly our point: Pre-weathering of plastic for laboratory experiments is mainly conducted by use of climate chambers with photooxidation, but do not the outcome of aging in soil (that we do not know). We now have emphasized that point.

[39] Line 396: The reviewer cannot understand why "photochemistry" is separated from "geochemical" reactions. Aren't photochemical reactions also "geochemical"? For instance, according to Wikipedia (quick check, and not a scientific source, but most likely accurate here): "Photogeochemistry is the study of light-induced chemical reactions that occur or may occur among natural components of the Earth's surface."

For clarification we added "soil (bio)geochemical" throughout the document.

[40] Line 402: "early material science". What is meant by "early"? Photochemical aging of plastics is extremely well studied but does not seem to be "the early days" of material sciences

Deleted.

[41] Line 423: "dimmed world"? Why dimmed? Is this not "dark"?

Not necessarily. There can be faint light within the upper centimeters. And you can dim something until its dark.

[42] Line 473: Is it reasonable to develop "THE" standard aging method for plastics in soils? See previous point

A standard approach, that includes influences by plastic type and additives but also so respective soil environment (e.g. arid/humid, active soil fauna, Corg).