Response to Reviewers

Dear Editor and Reviewers:

On behalf of my co-authors, I thank you very much for giving us the opportunity to revise our manuscript entitled "**Magnetic separation reveals overestimation of soil organic matter due to undecomposed particulate residues**" (Manuscript Number:**egusphere-2025-5686**).

We appreciate the positive and constructive comments from the reviewer. We have studied the comments carefully and tried our best to revise our manuscript accordingly. Revised portion are marked in **red** in the paper. Our point-by-point responses to the comments are attached, and the submitted manuscript has been improved and revised according to the comments. We hope that our responses and revisions are satisfactory and that our manuscript will now be acceptable for publication in Journal of "***SOIL***".

Again, we greatly appreciate your time and effort with manuscript. Should you have any further questions regarding the revised manuscript, please contact me by e-mail (dousen1959@126.com).

Best regards

Dou Sen

Corresponding author

Response to Editor

Response to Editor and revisions made accordingly (Italic words are the comments from the reviewer):

Response: We appreciate your thorough review of our work and the constructive comments provided to enhance the quality of our manuscript. Below are our point-by-point responses to your feedback. We sincerely hope the updated manuscript now meets the standards for publication in **SOIL.**

Dear Yuhan Xia and coauthors,

both referees agree that the manuscript has improved significantly.

However, also both agree that the way that SOM, POM and MOAM are referred to is inconsistent and confusing.

This must be improved.

For example, in the introduction you refer only to POM and SOM, claiming that SOM is strongly bound to minerals. Should this not be MAOM? It seems that when you refer to SOM in the introduction, you actually mean MAOM. I recommend that you stick to one clear operational definition of POM, MAOM as fractions of SOM that are stabilized by different mechanisms (chemical recalcitrance vs attachment to minerals).

Also, please (as recommended by both reviewers) reconsider sentences that claim that an increase in POM is falsely a seen by other researchers as increase in recalcitrant SOM. I think such statements are incorrect - it is common understanding of most researchers that while POM is part of SOM, it is in most cases not stable. In that context you may discuss the issue that biochar is also part of POM but stable.

And do you have proof that POM of microbial origin despite not being protected is more stable than POM of plant origin?

In summary, I agree with the reviewers that your work is novel and thus worthy of being published and I agree with them that your paper needs to reflect the current understanding of SOM and its fractions and pay attention to correctly addressing each fraction.

Please consider this feedback together with the other comments by the reviewers when preparing the next round of revisions.

Thank you

Response:

Dear Editor,

We are deeply grateful for your positive recognition of the improvements in our manuscript, as well as the rigorous and constructive feedback on the inconsistent usage of SOM, POM, and MAOM terminology and the inappropriate narrative in the text. We fully agree with the concerns raised by you and the two reviewers, and we will meticulously revise the manuscript in accordance with the current consensus on soil organic matter (SOM) fractionation and stabilization. Our detailed responses to your comments are as follows:

1. Unification of SOM, POM, and MAOM definitions and terminology

We acknowledge the confusion caused by the inconsistent and inaccurate use of SOM, POM, and MAOM in the original manuscript, especially the misstatement in the Introduction where “mineral-associated organic matter (MAOM)” was incorrectly

referred to as total SOM. We will systematically revise the entire text to establish a clear and consistent conceptual framework. We will correct the misleading description in the Introduction and ensure uniform use of these three terms throughout the manuscript, including in the results, discussion, and figure captions.

2. Revision of inappropriate statements regarding POM dynamics

We accept the comment that our original claim about other researchers “falsely interpreting increased POM as enhanced recalcitrant SOM” is inconsistent with the mainstream academic consensus that POM is generally a labile fraction of SOM. We will remove all such overgeneralized and inappropriate statements. Instead, we will objectively describe that the short-term increase in POM after organic amendment application is mainly derived from undecomposed exogenous residues, and emphasize biochar as a special case: although biochar is classified into the POM fraction, it exhibits high intrinsic chemical recalcitrance and long-term persistence in soil, which is distinctly different from ordinary labile plant-derived POM.

3. Clarification of the terminology error and research focus

We apologize for the typographical error in the relevant description: the phrase “microbially derived POM” was incorrectly written, and the intended meaning was microbially derived MAOM. In addition, the comparison between microbially derived and plant-derived POM is not the core research topic of this study. We will correct this terminology error in the manuscript and avoid unnecessary discussion of non-core content to ensure the narrative focuses on our research objectives.

4. Comprehensive revision integrating all reviewer comments

We will fully integrate the above revisions with all specific comments from the two reviewers, including adjusting inappropriate expressions, unifying POM-C terminology, optimizing result section headings, and correcting figure captions. All revisions will strictly align with the current theoretical understanding of SOM fractionation and stabilization.

We sincerely appreciate your valuable guidance and will complete all revisions carefully.

Sincerely,

Yuhan Xia and co-authors

Response to Reviewer 1

Response to Reviewer 1 and revisions made accordingly (Italic words are the comments from the reviewer):

Response: We appreciate your thorough review of our work and the constructive comments provided to enhance the quality of our manuscript. Below are our point-by-point responses to your feedback. We sincerely hope the updated manuscript now meets the standards for publication in **SOIL.**

In my view, the authors have done a thorough and commendable job of responding to the concerns of both reviewers.

There are only a few places left in the text where there are references to the old framing of "false increases" of POM, and these should be adjusted. The headings of the results sections should also be rewritten. See lines 260, 321, 355, 373, 418, 425.

Additionally, in 3.5, the change to POM-C should be reflected throughout the text and in the caption of Figure 5.

Following these minor changes, I believe the manuscript should be published as is.

Response: We greatly appreciate your positive evaluation of our revision and your careful check of the remaining details in the manuscript.

We have carefully revised all the remaining expressions related to the old framing of “false increases” in POM at the indicated lines (Lines 260, 321, 355, 373, 418, and 425) to ensure consistency with the current conceptual framework. We have also rewritten the headings of the results sections to better match the revised content.

Furthermore, in Section 3.5, we have updated the term to POM-C throughout the text and revised the caption of Figure 5 accordingly to maintain full consistency.

All suggested minor revisions have been completed. We sincerely thank you for your constructive comments and support for our manuscript.

Response to Reviewer 2

Response to Reviewer 2 and revisions made accordingly (Italic words are the comments from the reviewer):

Response: We appreciate your thorough review of our work and the constructive comments provided to enhance the quality of our manuscript. Below are our point-by-point responses to your feedback. We sincerely hope the updated manuscript now meets the standards for publication in **SOIL.**

General comments

The paper underwent significant improvement since the first round of review. There are still occurrences of misconception and miswording regarding the nature of POM and the legitimate place of undegraded residues in SOM which must be corrected before publication.

Here, you talk about 'false increase' as if it was a common mistake made by people when considering POM. I am not sure many papers pretend that an increase in POM corresponds in any way to stable carbon. If you have some papers in mind that make this mistake, cite and discuss them directly and very specifically. But the mistake would be considering undegraded matter as stable, not considering it as part of SOM.

However, if you want to discuss extensively the nature of POM and belonging (or not) of undegraded residues in SOM, I would advise you submit your reflection as an opinion paper rather than a research article, as it allows for broader discussion of otherwise established concepts.

Specific comments

Comments 1: *L18: what do you mean by 'native'?*

Response: Thank you for the constructive suggestion. The term "native" in the original text refers to indigenous soil organic matter inherently formed through microbial transformation and mineral association in the soil, rather than externally added undecomposed plant, straw or biochar residues.

To eliminate ambiguity and enhance the clarity of expression, we have revised the sentence in Page 2, Lines 17-19 of the Abstract to: "Conventional analytical methods cannot clearly distinguish undecomposed exogenous organic residues from indigenous soil organic matter (SOM)."

Comments 2: *L30: '(MCS-D and MBc-D)' are not reused later in the abstract itself, so it is not necessary to introduce these abbreviations.*

Response: We thank the reviewer for this careful and helpful comment. As suggested, the abbreviations (MCS-D and MBc-D) are not reused elsewhere in the abstract, so we have deleted these unnecessary abbreviations and revised the relevant sentence accordingly. The sentence has been revised in Page 2, Lines 30-31 to: "However, after removing undegraded residues by magnetic separation, values were close to those of CK."

Comments 3: *L44: these undecomposed residues are also part of SOM. I would advise to reword the beginning of this paragraph as follows: 'Soil organic matter (SOM) is a complex assemblage of organic compounds formed through the accumulation, decomposition and transformation of plant and animal residues. The decomposed part exhibits a much stronger binding capacity to soil minerals than undecomposed or partially decomposed residues. This strong binding makes it one of the most stable organic fractions in soil and supports its long-term persistence.' In this way, it makes sense to distinguish afterwards between what you will call stabilized/stable SOM and the rest which is still part of SOM. Especially as you*

highlight the importance of the nutrients supplied by labile SOM: if this SOM can be easily decomposed to provide nutrients, then it is not stable/stabilized.

Response: We are very grateful for the reviewer's professional and insightful comment. As the reviewer pointed out, undecomposed exogenous organic residues are also an integral component of total soil organic matter (SOM), and the original expression was ambiguous in distinguishing between decomposed stable SOM fractions and undecomposed/partially decomposed SOM components.

We have strictly revised the beginning of the Introduction paragraph in accordance with the reviewer's suggested wording. The revised expression clearly defines that SOM includes both accumulated undecomposed residues and microbially decomposed stable fractions, which makes the subsequent distinction between stabilized SOM and exogenous undecomposed residues more logical and rigorous. This revision also avoids the conceptual contradiction between labile SOM (providing nutrients via decomposition) and stable mineral-associated SOM.

The modified sentences has been revised in Page 4, Lines 43-47 as follows: "Soil organic matter (SOM) is a complex assemblage of organic compounds formed through the accumulation, decomposition and transformation of plant and animal residues. The decomposed part exhibits a much stronger binding capacity to soil minerals than undecomposed or partially decomposed residues. This strong binding makes it one of the most stable organic fractions in soil and supports its long-term persistence."

Comments 4: *L66: it is not spurious. It is a real increase in a specific kind of OM that is characterized by a usually shorter residence time and high exposure to decomposition. Please change the wording. Same L70 and L103. Same L260 with 'false increases', as well as L321 in your 3.3 title and in L355; L373 in your 3.4 title; L342 'artificial'; L418 in 3.5 title; L425. It is part of POM and SOM, as you rightfully added it in your discussion.*

Response: We sincerely appreciate the reviewer's rigorous and critical comment on the wording of "spurious", "false" and "artificial". We fully agree with the

reviewer that the increases in POM induced by undecomposed exogenous organic residues are real and legitimate components of total SOM and POM, rather than false or artificial increments. These increases only represent a labile fraction of SOM with shorter residence time and higher susceptibility to microbial decomposition, instead of microbially stabilized organic carbon.

Accordingly, we have deleted all inappropriate terms including "spurious", "false increases" and "artificial" throughout the manuscript, and uniformly replaced them with accurate expressions such as residue-derived increases, transient increases, non-stabilized increases and residue-driven increases. This revision ensures the conceptual consistency between our results and the basic definition of SOM, and clearly distinguishes labile residue-derived POM from stable mineral-associated SOM, which greatly improves the scientific rigor and accuracy of the expression.

For example, the sentence in Page 5, Lines 66-69 has been revised as follows:

"This increase is transient and non-stabilized, as POM remains susceptible to decomposition and transformation even under the physical protection of soil (Connell et al., 2025), and such short-term increases exhibit low persistence in soil (Janzen, 2015; Powlson et al., 2014)."

All corresponding inappropriate words in other positions (L70, L103, L260, L321, L342, L355, L373, L418, L425) have been revised in the same manner to maintain conceptual unity and scientific accuracy.

Comments 5: *L97: 'was used to turn'? (missing word?)*

Response: Thank you for the careful correction. There was an improper expression in the original manuscript at Line 97. We have revised in Page 6, Lines 98-99 to: "In this study, a chemical coprecipitation method was used to composite straw (CS) and straw biochar (Bc) into magnetic materials." The corresponding description in the manuscript has been updated accordingly.

Comments 6: *L191–194: unless I am mistaken, this is not consistent with what you state L194–201. Please correct accordingly.*

Response: We sincerely appreciate the reviewer for pointing out the inconsistent description of the SOC determination method.

We have revised the relevant statements in Lines 191–194 and Lines 194–201 to clarify the experimental logic: the potassium dichromate oxidation method was only used for the preliminary characterization of organic carbon in the original soil, while all formal and reported SOC data in this study were consistently measured using an elemental analyzer.

The inconsistent expression has been corrected accordingly.

Comments 7: *L273: I would be very cautious with the use of 'stabilized'. Here in Fig. 1 you just check for degradation. You have no evidence of stabilization. Especially, when talking about stabilization, it is necessary to indicate which duration you are considering. The evolution of the chemical nature, indicating potential stabilization, only comes with Fig. 2.*

Response: Thank you for the constructive comment. We acknowledge that "stabilized" is inappropriate here as Fig. 1 only presents degradation rather than direct stabilization evidence. The expression has been revised to "relatively recalcitrant organic matter", and the evidence for organic matter stabilization will be further elaborated in conjunction with Fig. 2.

Comments 8: *L383: do you mean the increase in POC content (instead of SOC)?*

Response: We thank the reviewer for carefully identifying this typographical error.

The description at Line 385 incorrectly used "*SOC*" instead of "*POC*". This paragraph focuses on the changes in particulate organic carbon (POC) content, while SOC content is discussed in the following paragraph.

We have corrected "*SOC*" to "*POC*" in the manuscript to ensure consistency and accuracy in the description.

Comments 9: *L454–458: correct me if I don't understand it well, but you are talking here about the transformations that happen in the magnetic straw residues. If they are magnetic, it means they have not been degraded. However their composition varies? And towards a more stable form?*

Response: We greatly appreciate the reviewer for this insightful question and for clarifying the potential misunderstanding in our original description.

To address this confusion, we have revised in Page 24, Lines 454–463 to explicitly distinguish between the organic fraction and the magnetic mineral fraction in the magnetized straw residues:

The observed shifts in H/C and O/C ratios are attributed to the degradation, oxidative transformation, and structural condensation of the straw-derived organic components within the magnetic materials, rather than the entire residue being completely undegraded.

The persistent magnetic properties of the residues arise from the stable magnetic mineral phase that remains intact during incubation, even as the organic straw fraction is decomposed and chemically modified toward more stable forms.

The description has been revised accordingly to ensure clarity and accuracy.

Comments 10: *L524: just as a remark: not only! MAOM also forms with the help of earthworms, for instance. So it can form at shorter timescales.*

Response: We sincerely appreciate the reviewer for this valuable and constructive remark.

We agree that the formation of MAOM is not restricted to long-term weathering processes alone, and biotic interactions (such as earthworm activities) can indeed contribute to MAOM formation over shorter timescales.

We have revised the statement in Page 27, Lines 528-532 to supplement this important point, making the description of MAOM formation pathways more comprehensive and accurate.

Comments 11: *L530: 'cause MAOM formation' → what do you mean? That because it is not degraded (not eaten because too hard), it will persist in soil until it gets adsorbed onto minerals instead of being respired? Or because micro-organisms will eat it but not digest it, so it will get mixed with minerals more easily after passing through organisms? If you mean the first, then I don't understand the sentence L531–533; if you mean the second, it makes more sense to me, as the Bc will not be eaten at all so will hardly be mixed with minerals. Maybe you could clarify this. However, I'm not sure to understand your sentence L533–535: in MBc-D, you removed the undegraded part, which was mostly in POM, so this should increase the MAOM contribution, compared to Bc where, as you said, the MAOM contribution is smaller. But you now state it is higher for Bc than for MBc-D? Sorry if I'm mistaken.*

Response: We greatly appreciate the reviewer for these very constructive comments and for carefully pointing out the confusion in our description. We apologize for the unclear expression and the potential misunderstanding caused.

To clarify our intended meaning and correct the ambiguity:

The mechanism we intended to describe corresponds to the first scenario suggested by the reviewer. Biochar is highly recalcitrant and resistant to microbial decomposition, so it mainly persists as undecomposed particles in the POM fraction rather than being rapidly mineralized. Only a small part can interact with minerals to form MAOM. Since biochar is barely utilized by microorganisms, the second pathway (processing by organisms and subsequent mixing with minerals) is not the main mechanism in our study.

We sincerely apologize for a critical typo in Lines 537-541. The phrase "higher MAOM contribution" was incorrectly written; what we actually meant and observed was higher POM-C contribution in the CS and Bc treatments than in the MCS-D and MBc-D treatments.

In CS and Bc, large amounts of undecomposed organic residues remained in the POM fraction, leading to a high POM contribution.

In MCS-D and MBc-D, the undecomposed particulate residues were removed, so the POM contribution decreased accordingly, while the relative contribution of

MAOM increased. This typo led to an apparent logical contradiction, which we have now corrected in the manuscript.

The relevant sentences have been revised to ensure clarity and consistency with our data and interpretation.

Comments 12: *L545: 'However, most of the short-term increase originated from undecomposed amendment residues retained in the POM fraction rather than from microbially transformed and stabilized organic matter' → I don't see the problem you try to highlight. It is quite logical that the short-term increase originates from the POM, because if it originated from the stabilized organic matter, then it wouldn't be short-term. Also, if it resides in soil for a short period of time, it means it is quickly mineralized, so it does supply nutrients; if it stays in the soil and is not used by micro-organisms, then it doesn't promote microbial activity.*

Response: We sincerely appreciate the reviewer for this insightful comment and for clarifying the logical relationship between short-term organic carbon accumulation and carbon pool stability.

Our original intention in this statement was not to question the rationality of short-term carbon increase originating from the POM fraction, but to distinguish the source of the short-term organic carbon increment: the elevated organic carbon in the early incubation stage was mainly contributed by the undecomposed particulate organic residues from exogenous amendments, rather than the stable mineral-associated organic matter (MAOM) formed through microbial transformation and mineral binding.

We fully agree with the reviewer that short-term retained organic carbon in POM is readily available for microbial mineralization and can effectively supply nutrients

and support microbial activity, whereas stable organic matter pools are less biologically accessible in the short term. To avoid misunderstanding, we have revised the expression in Lines 551-554 (Page 28) to clarify this distinction more accurately, while aligning with the logical relationship you proposed. "Notably, the observed short-term increase in soil organic carbon was primarily derived from undecomposed exogenous organic residues retained in the particulate organic matter (POM) fraction, rather than the formation of microbially processed and mineral-associated stable organic matter pools."

Comments 13: *L568: in which studies did you read this interpretation? Why would POM increases be interpreted as SOM stabilization? POM is globally considered as a labile fraction. More POM would mean less stable SOM.*

Response: We sincerely appreciate the reviewer for this rigorous and professional comment, which has greatly helped us improve the accuracy of our description.

We fully agree with the reviewer that particulate organic matter (POM) is universally recognized as a labile fraction of soil organic matter, and an increase in POM does not represent SOM stabilization. Our original expression was ambiguous and misleading.

Our intended meaning was that some studies simply take the increase in POM content after organic amendment application as a sign of organic carbon sequestration or microbial transformation of organic matter, without distinguishing whether the newly increased POM is derived from stable organic components or undecomposed

exogenous residues.

We have revised the relevant statement in Lines 574-579 to avoid misunderstanding: we no longer link POM increase to SOM stabilization, and clearly emphasize that POM is a labile pool, and the increased POM in this study is mainly untransformed exogenous organic residues. The revised description is more consistent with the common understanding of POM biogeochemical characteristics. "After organic material addition, the accumulation of the operationally defined POM fraction is frequently regarded as an indicator of enhanced soil organic carbon sequestration or microbially mediated organic matter transformation. However, as a labile organic pool, the elevated POM observed in this study was largely derived from recalcitrant and untransformed exogenous amendment residues, rather than the formation of chemically stable soil organic matter."

Comments 14: *Same question L585: you say it is 'persistent recalcitrant materials': pyrogenic carbon is indeed one of the exception to the usual lability of POM, so it will persist in soil, it is not a misinterpretation.*

Response: We sincerely appreciate the reviewer for this valuable and precise comment.

We fully agree with the reviewer that pyrogenic carbon (biochar) represents a well-recognized exception to the typical lability of particulate organic matter (POM), and its long-term persistence in soil is an inherent characteristic rather than a misinterpretation.

Our original statement aimed to emphasize that in short-term trials, the presence of highly recalcitrant exogenous materials like biochar (which remains as a stable POM fraction) can easily lead to an overestimation of soil organic matter stabilization, as this persistence stems from the intrinsic recalcitrance of the amendment itself, not from the formation of microbially transformed and mineral-associated stable organic matter pools.

We have revised the description at Lines 593-598 to explicitly acknowledge the special status of pyrogenic carbon and clarify the underlying mechanism, making the statement more accurate and consistent with the biogeochemical properties of POM. "This risk is particularly evident in short-term incubation studies or agroecosystems receiving recent organic amendments, especially when incorporating pyrogenic carbon such as biochar. As a notable exception to the general lability of POM, such persistent recalcitrant materials can lead to an overestimation of soil organic matter stability, as their persistence arises from inherent chemical recalcitrance rather than microbially mediated stabilization processes."