

***Interactive comment on* “Reviews and syntheses: Heterotrophic fixation of inorganic carbon – significant but invisible flux in global carbon cycling” by Alexander Braun et al.**

Anonymous Referee #1

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I was very excited to see this synthesis and review paper on heterotrophic CO₂ fixation because heterotrophic CO₂ fixation is currently not well understood despite indications that it is quantitatively important in several ecosystems. I started reading the manuscript with great interest, but unfortunately, found the manuscript increasingly disappointing for the following reasons.

(1) Simplistic estimation of global fluxes: The main synthesis work done by the authors in the present study is summarized in the two tables of the manuscript. Table 1 gives the global standing stock of organic carbon in living biomass and the contribution from anaerobic CO₂ fixation. In this table, the authors compiled data on C stocks in dif-

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ferent biomass pools. Next, they multiplied the stocks of biomass of heterotrophs by 0.02 and 0.08 and the stocks of biomass of photoautotrophs by 0.01 and 0.05 in order to estimate the contribution from anaplerotic CO₂ fixation. Likewise, in Table 2 the authors compiled data on the annual global heterotrophic carbon biomass production for different ecosystems and multiply it by 0.02 and 0.08 in order to estimate the contribution from anaplerotic CO₂ fixation. In the first part of the manuscript, the authors point out that there is large uncertainty concerning the rates of microbial heterotrophic CO₂ fixation and the underlying metabolic pathways. I agree with this view, and was very surprised to see that the authors estimate global rates of heterotrophic CO₂ fixation based on a simple multiplication. I find it highly questionable to base a review paper on this kind of back on the envelop calculation, and I do not see the value of this estimation given how little we know about the size of the flux in different ecosystems.

(2) Lack of synthesis of empirical data: From a review and synthesis paper on heterotrophic CO₂ fixation, I would expect a review of empirically determined CO₂ fixation rates. Unfortunately, this is lacking in the present manuscript. For some inspiration, the authors should have a look at the recent study by Akinyede et al., 2020 who nicely compiled data on heterotrophic CO₂ fixation in soils in a table that gives a good overview.

(3) Unclear scope and unbalanced review of literature: According to the title and the Introduction of the manuscript, the topic of the manuscript is heterotrophic fixation of inorganic carbon. However, the manuscript focuses very strongly on CO₂ fixation through anaplerotic reactions and pays less attention to other pathways of heterotrophic CO₂ fixation. More importantly, the manuscript concentrates strongly on literature about aquatic ecosystems and largely ignores literature about heterotrophic CO₂ fixation in terrestrial ecosystems. This is problematic given that the authors state that the manuscript has a global scope.

(4) Unfocused and unclear figures: I like Fig. 2 because it gives a good overview over different pathways. However, I did not understand the purpose of Fig. 1 and the reason why it only shows one pathway. I guess that the purpose of the figure is mainly to show

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that the CO₂ can be derived either from cell-internal or cell-external processes. While this might be important for the estimation of fluxes, I'm not fully convinced that this requires a separate figure. More importantly, I did not understand Fig. 3. According to the caption the figure shows how much CO₂ is fixed when microbes feed on different carbon substrates. However, somehow the gist seems to be that this is always 8% as indicated by the grey area. What I did not understand is the meaning of the black line and why it goes up all the way to 45%. Maybe a legend would be helpful here?

I am sorry that I cannot provide a more positive review of this synthesis study. I hope that my criticism is clear and that it provides some guidance on how to improve the synthesis study.

References

Akinyede, R., Taubert, M., Schrumpf, M., Trumbore, S., & Küsel, K. (2020). Rates of dark CO₂ fixation are driven by microbial biomass in a temperate forest soil. *Soil Biology and Biochemistry*, 150, 107950.

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