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Removal of atmospheric nitrous oxide (N2O) using Photocatalytic Technology

Review

External R1 Review Round

[Reviewer #2]

April 2025

CONTENT referenced by reviewer's comment *e.g. Section number + paste exact text*	**REVIEWER'S COMMENT** *Please paste the comment from the reviewer*	**AUTHOR'S RESPONSE** *Please describe how the comment was addressed and include new content in quotations*	**Reviewer's Conclusion** [PASSED/ REJECTED *WITH COMMENTS*]
e.g. 2.1 - "approximately 25%	***e.g. Replace*** *with "adequate"*	*e.g. This was changed to* ***"The majority of the material must have a moisture content of 25% or less, as measured in the field."***	*PASSED*

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Reviewer's Blind Review Comments regarding Credit Class

Kindly enter your comments based on these questions in the table below. Also, if referencing specific text, please include text excerpt or row/page number from the credit class for ease of reference by the authors. All reviewer comments will remain anonymous unless you choose to be named.

Is the credit class clearly written with adequate detail for implementation?	No, the proposed methodology does not provide scientific evidence to demonstrate that the protocol for "Quantifying GHG Emissions Removals" is effective in measuring the climate benefits of the technology used.
Is the underlying foundation of the credit class clear?	No, there is a lack of scientific evidence for the N2O removal provided by photocatalytic technology.
Is the credit class feasible?	No, there is no scientific evidence for the removal of N2O that photocatalytic technology promotes.
Are there any alternative or additional points that should be considered?	In addition to the scientific basis in a peer-reviewed literature, I suggest that the application of the "Quantification of GHG Emissions Removal" protocol (instruments and calculations) be applied in the project area (i.e., where the product that promotes the photocatalytic occurrence of N2O breakdown was applied), and in a control area (i.e., where no product was applied) the difference in N2O concentrations represents the verified N2O removal.

Will the proposed guidelines and regulations achieve the results defined in the credit class?	I do not believe that this is possible, as described above.
Do you want to be named in the review? (Expert Reviewers will be anonymous unless you choose to be named)	No

Recommendation

Kindly mark with an X

Accept As Is:	
Requires Minor Revision:	
Requires Moderate Revision:	
Requires Major Revision:	
Reject and Re-submit:	
Rejection: (Please provide reasons)	X (see below)

General/Additional Comments:

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- This proposed methodology makes a great effort to present the impacts of agriculture on N2O emissions, as well as its high global warming potential, these facts are already recognized;

- The photocatalytic technology for breakdown N2O developed by Crop Intellect Ltd (R-Leaf) can apparently be implemented on any suitable surface that can receive and retain the photocatalyst. However, the bibliographic referential provided does not show the product applied in the field, only in experiments in laboratories and closed environments;

- In addition, I believe that the methodology should present the active ingredients that promote the photocatalytic reaction for breakdown N2O, not a specific brand product, which makes the methodology dependent on a specific product supplier;

- The proposed methodology focuses efforts on the data traceability on the acquisition and application of the product in the field, seeking to ensure the principes of “relevance” and “completeness”, however it does not have a scientific basis to guarantee “consistency”, “accuracy”, “transparency” and “conservatism”;

- The proposed methodology applies photocatalytic technology to breakdown N2O does not have a benchmark or a solid reference in peer-reviewed literature that proves that the "Quantification of GHG Emissions Removal" protocol (instruments and calculations) is capable of accurately determining the efficiency of the method in removing atmospheric N2O;

- An alternative - I believe that, in addition to validation through a solid peer-reviewed scientific literature reference, it is possible that the application of the "Quantification of GHG Emissions Removal" protocol (instruments and calculations) should be applied in the project area (i.e., where the product that promotes the photocatalytic reaction to breakdown N2O was applied), and in a control area (i.e., without application of the product) the difference in N2O concentrations should represent the verified N2O removal.

Reviewer’s Blind Review Comments regarding Methodology

Kindly enter your comments based on these questions in the table below. Also, if referencing specific text, please include text excerpt or row/page number from the methodology for ease of reference by the authors. All reviewer comments will remain anonymous unless you choose to be named.

Is the methodology clearly written with adequate detail for implementation?	No
Is the underlying foundation of the methodology clear?	No
Is the methodology feasible?	No
Are there any alternative or additional steps that should be considered?	No
Will the proposed processes for data collection and verification achieve the results defined in the methodology?	No
Do you want to be named in the review? (Expert Reviewers will be anonymous unless you choose to be named)	No

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Recommendation

Kindly mark with an X

Accept As Is:	
Requires Minor Revision:	
Requires Moderate Revision:	
Requires Major Revision:	
Reject and Re-submit:	
Rejection: (Please provide reasons)	X

General/Additional Comments:

As explained, and reiterated, there is a more serious problem beyond the credit class and clarity and application of the methodology.
The materiality of the proposed technology - photocatalysis for breakdown N2O, has not been confirmed in the field, only in laboratory experiments and indoor environments, in which conditions are controlled.
The equations presented to calculate the technology efficiency, and which support the quantification of GHG emission removals, and consequently, removal credits issuance, are general gas fluxes equations, i.e., empirical to estimate N2O removals due to photocatalytic technology.
In this sense, my suggestion is that proponents dedicate efforts to scientific studies that can better support photocatalysis technology for breaking down N2O, as well as measurement protocols with greater accuracy.

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Author's Response:

The R-Leaf® atmospheric nitrous oxide (N_2O) removal methodology has undergone extensive independent review, validation, and approval. While an earlier version was initially submitted to Regen Network, progress was delayed as expert reviewers with the required specialist knowledge were identified. In parallel, the methodology was submitted to the International Carbon Registry (ICR), an ICROA-accredited registry, where it successfully completed a full review process including third-party validation by Enviance Ltd, an experienced Validation and Verification Body (VVB). This independent assessment confirmed that the methodology meets the robustness, conservatism, and transparency requirements of ICR v6.0 and ISO 14064-2.

We would like to acknowledge Reviewer #2's constructive comments, which focused primarily on the need for field-scale scientific evidence, clarity around product dependence, and the robustness of verification protocols. These concerns have now been addressed. The peer-reviewed field scale study Bueno-Alejo, Khambhati and Papadopoulos (2025), which is referenced in the methodology, demonstrates N_2O mitigation using photocatalyst in agricultural fields and is backed by evidence from Bueno-Alejo *et al.* (2025). The methodology incorporates the use of control areas for verified quantification of N_2O removal and is applicable to any photocatalytic technology with proven capacity to break down N_2O under visible light, including but not limited to R-Leaf®. The quantification protocol and equations are aligned with ISO standards to ensure accuracy, transparency, and replicability.

The methodology is now formally approved and published by ICR as a validated carbon credit standard for atmospheric N_2O removal.

References:

Bueno-Alejo, C.J., Khambhati, Y.K. and Papadopoulos, A., 2025. Photocatalytic removal of N_2O in cropped fields using R-Leaf. Applied Catalysis O: Open, 207032.

Bueno-Alejo, C.J., Khambhati, Y.K., Papadopoulos, A., Reli, M. and Ricka, R., 2025. Using photocatalysis for sustainable agriculture: R-Leaf's potential in large-scale N_2O mitigation. Journal of Hazardous Materials Advances, 18, p.100703.