Science of the Total Environment 760 (2021) 143397

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Contribution of the Fenton reaction and ligninolytic enzymes to soil organic matter mineralisation under anoxic conditions

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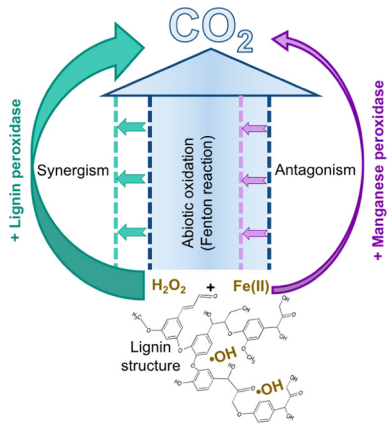
HIGHLIGHTS

- Fenton reaction and oxidative enzymes explain high CO_2 efflux from anaerobic soils.
- Synergism of Fenton reaction and lignin peroxidase activity induce high CO_2 efflux.
- $H_2^{18}O_2$ labelling allows identifying and differentiating abiotic oxidative processes.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 3 June 2020
Received in revised form 26 October 2020
Accepted 28 October 2020
Available online 5 November 2020

Editor: Paulo Pereira

Keywords:
Fenton oxidation
Anoxic environment
Hydrogen peroxide
Ligninolytic and oxidative enzymes
Carbon cycle

ABSTRACT

Mechanisms of carbon dioxide (CO_2) release from soil in the absence of oxygen were studied considering the Fenton process, which encompasses the reaction of H_2O_2 with Fe(II) yielding a hydroxyl radical (•OH), in combination with manganese peroxidase (MnP) and lignin peroxidase (LiP). This study aimed to explain the high rate of soil organic matter (SOM) mineralisation and CO_2 release from humid temperate rainforest soils under oxygen-limited conditions. The investigated mechanisms challenge the traditional view that SOM mineralisation in rainforest is slow due to anaerobic (micro)environments under high precipitation and explain intensive CO_2 release even under oxygen limitation. We hypothesised that the Fenton reaction (FR) greatly contributes to the CO_2 released from SOM mineralised under anaerobic conditions especially in the presence of ligninolytic enzymes. We used a novel technique that combines labelled $H_2^{18}O_2$ and Fe(II) to induce the FR and measured $CO^{18}O$, Fe(II) solubilisation, and peroxide consumption in a closed gas circulation system for 6 h. Maximal CO_2 amount was released when the FR was induced in combination with LiP addition. The CO_2 efflux with LiP was 10-fold that of abiotic FR reactions without enzymes, or in soils amended with MnP. This was consistent with i) the contribution of ^{18}O from peroxide to CO_2 release, ii) peroxide consumption, and iii) Fe(II) solubilisation by FR.

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https://doi.org/10.1016/j.scitotenv.2020.143397