Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.26269

Microbial Respiration of Wildfire Chars and Its Biogeochemical and Climate Impacts

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The warming climate has increased the frequency and intensity of wildfires, which can further exacerbate climate change. Here we report biogenic methane (CH_4) suppression by wildfire chars, a previously unrecognized, potentially beneficial impact of wildfires on climate. We hypothesized that all chars derived from wildfires possess an electron storage capacity (ESC) that can support char-respiring microorganisms, enabling them to outcompete methanogens and thus suppress CH_4 production. A total of 18 chars from wildfires that occurred between March and October 2023 were collected from 4 U.S. states and Washington D.C. All chars possessed significant ESC, from 0.62 to 2.85 mmol e^-/g in the E_H range between −0.36 V to +0.81 V vs. SHE. Without char, singly ^{13}C-labeled acetate ($^{13}CH_3{}^{12}COO^-$) was converted by a mixed culture into equimolar $^{13}CH_4$ and $^{12}CO_2$. In the presence of an air-oxidized char, $^{13}CO_2$ was produced at the expense of $^{13}CH_4$, indicating that anaerobic char respirers outcompeted acetoclastic methanogens. Char electron contents measured before and after acetate degradation showed that, electrons that would otherwise end up in CH_4 were deposited into char instead. Electron balance shows that approximately 28.4±2.2% of the wildfire chars' ESC was used by microbes to divert electrons away from CH_4 production. Air oxidation of chars retrieved from acetate degradation experiments restored the chars' capacity to suppress CH_4, confirming the redox-reversible and regenerable nature of the ESC. These findings improve our understanding of, and ability to assess, the full climate impacts of wildfires and deforestation. The study provides the first dataset of wildfire char ESC, as well as the first quantitative demonstration of biogenic CH_4 suppression by wildfire chars.