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A New Climate Impact of Wildfire Chars: Suppression of Biogenic Methane Production Over Repeated Redox Cycles

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ABSTRACT

The warming climate has increased the frequency and intensity of wildfires, which can further exacerbate climate change. Here we report the suppression of biogenic methane (CH_4) by wildfire chars, a previously unrecognized, potentially beneficial impact of wildfires on global climate. We hypothesized that char derived from wildfires possess an electron storage capacity (ESC) that can support char-respiring microbes, enabling them to outcompete methanogens. A total of 18 chars from fires that occurred between March and October 2023 were collected from across the U.S. All chars possessed sizable ESC, from 0.54 to 2.85 mmol e^-/g in the E_H range of −0.36 to +0.81 V. Without char, singly ^{13}C-labeled acetate ($^{13}CH_3{}^{12}COO^-$) was converted by a wastewater 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 $^{13}CH_4$, as 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. On average, 28.4 ± 2.2% of the wildfire chars' ESC was utilized to divert electrons away from CH_4. Aeration of microbially utilized chars restored the chars' capacity to suppress CH_4, confirming the redox-reversible nature of ESC. These results improve our understanding of, and ability to assess, the full climate impacts of wildfires and deforestation. This study provides the first significant data set of wildfire char ESC, and the first quantitative demonstration of CH_4 suppression by wildfire chars.

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