Riverine Microbial Degradation of Pyrogenic Dissolved Organic Matter from Wildfire Ash

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Background

Wildfires leave partially burned organic matter behind as ash, which is readily dissolved by post-fire rainfall, inundating aquatic environments with pyrogenic dissolved organic matter (PyDOM), a source of dissolved carbon and nitrogen. This increase in PyDOM concentration can lead to a host of environmental water quality issues. Presently, biogeochemical outcomes of PyDOM are not fully understood. Previous studies using lab-created ash have shown that riverine microbes can biodegrade PyDOM, ultimately returning it to the atmosphere as CO_2 and N_2. This study is the first to test this proof of concept using wildfire ash. As wildfires increase in frequency and intensity due to climate change, further understanding of this phenomenon will be necessary.

Methods

Figure 1: (a) The LNU Lightning Complex Fire burns chaparral in Lake Country, CA (Photo credit: Noah Berger, NPR). Ash of presumed (b) low, and (c) high temperature combustion are shown for color comparison

Ash from different presumed burn temperatures was collected from Lake County, CA after the LNU Lightning Complex Fires in October 2020. PyDOM was leached from the ash for 48 hours into Milli-Q water and filtered at 0.2 µm. River water collected from the Palouse River, WA (46°43'51.9"N, 117°10'25.7"W) was used to inoculate samples, which were incubated at room temperature for 14 days on a mechanical shaker, open to the atmosphere. Dissolved organic carbon (DOC) concentration, dissolved organic nitrogen (DON) concentration, total nitrogen (TN) and concentrations of other nitrogen species were tracked. UV-absorbance was measured, and microbial concentration in samples and controls was assessed. Controls had lower microbial density than inoculated samples, but weren't entirely abiotic, as soil microbes persisted despite filtration.

Results

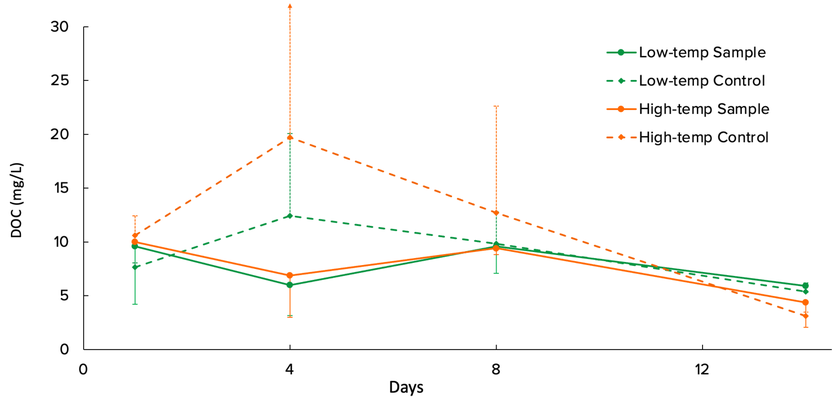

Figure 2: DOC decreases over time in inoculated PyDOM samples. Scatterplots show changing DOC concentrations in low and high temperature samples inoculated with river water, and in low and high temperature controls.

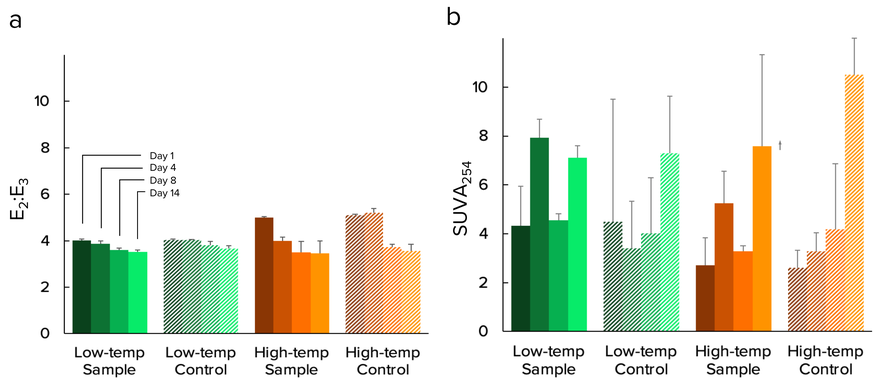

Figure 3: E_2:E_3 values decrease, while Specific Ultraviolet Absorbance at 254 nm ($SUVA_{254}$) increases over time in inoculated PyDOM samples. Bar plots show (a) E_2:E_3 values and (b) $SUVA_{254}$ values for low and high temperature inoculated samples and controls.

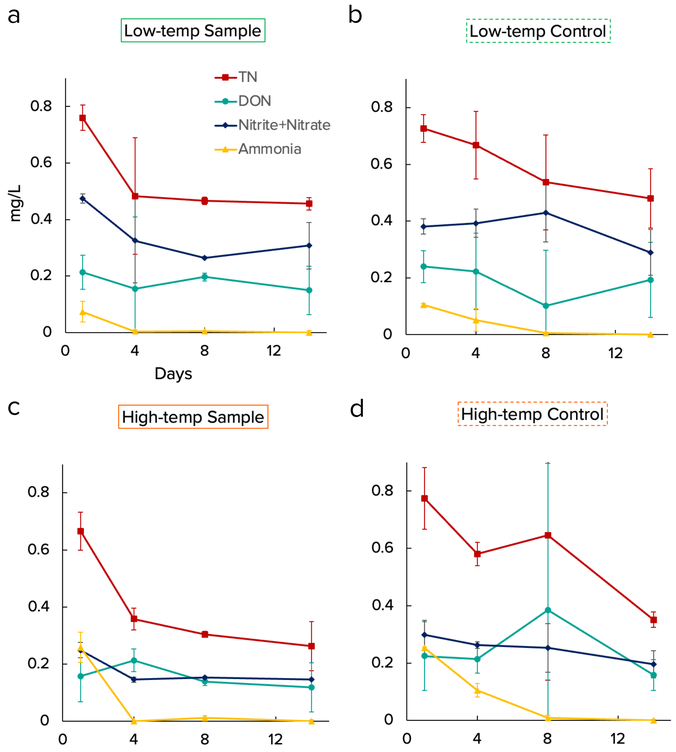

Figure 4: TN, DON, and inorganic nitrogen species decrease over time in inoculated PyDOM samples. Scatterplots show changing concentrations of nitrogen species for (a) inoculated low temperature samples, (b) low temperature controls, (c) inoculated high temperature samples, and (d) high temperature controls.

Conclusions

Riverine microbes degrade PyDOM from wildfire ash. DOC concentrations decrease over time, with a more rapid decreases seen in samples inoculated with riverine microbes compared to controls (figure 2). TN concentrations similarly decrease, more quickly in inoculated samples than in controls. The decrease of DON is more subtle but is still prevalent, primarily in inoculated samples. Inorganic nitrogen species decrease over time, indicating a return of nitrogen to N_2 (figure 4). E_2:E_3 values decrease over time, especially in high temperature PyDOM samples, showing an increase in molecular weight, indicating that smaller PyDOM was degraded more readily (figure 3a). $SUVA_{254}$ values increase, more rapidly in inoculated samples, signifying an increase in aromaticity over time, suggesting biodegradation of the aliphatic portions of the PyDOM leachate (figure 3b).

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