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Inferred bioavailability of pyrogenic organic matter in comparison to natural organic matter from global sediments and surface waters

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Wildfires are increasing in frequency, severity, and area burned in response to pervasive hotter and drier conditions, creating a multitude of negative consequences for aquatic ecosystems. Pyrogenic materials generated by wildfires are transported across terrestrial landscapes into inland waters, where approximately 10% of organic matter pools is comprised of black carbon. While recent work suggests pyrogenic organic matter (PyOM) is more bioavailable than indicated by traditional paradigms, the heterogeneity of PyOM pools generated through various feedstocks and combustion scenarios complicates our efforts to understand its bioavailability. Here, we use a mathematical model to predict the energy content, metabolic efficiency, and rate of aerobic decomposition of representative PyOM compounds. We compare these metrics to model outputs derived from measured natural organic matter in global surface waters and sediments to assess differences in bioavailability. We find that PyOM generally has a similar range of bioavailabilities to that of natural systems. However, phenols and black carbon (defined as highly condensed molecules with high solubility) have lower metabolic efficiency than most representative PyOM classes and natural organic matter pools, denoted by higher lambda and lower carbon use efficiency. Rates of aerobic metabolism of phenols and black carbon are also less negatively impacted by oxygen limitation than any other group. Overall, our work suggests that PyOM may be more bioavailable than previously thought and could be an unrecognized contributor to global C emissions as the prevalence of wildfires increases.