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Beyond PM2.5: Wildfire production and dispersion of toxic metal soil particulates

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Wildfires are increasing in severity, frequency, and distribution globally. While essential for ecosystem function, increasing fire severity is leading to devastating impacts on ecosystem processes. Although appreciable attention has been devoted to fine particulate matter derived from wildfires, the production of toxic metals within fine particulate matter has largely gone unrecognized. Of the toxic metals, soil- and plant-borne chromium is particularly problematic, being transformed from the benign trivalent to the highly toxic hexavalent state. We use a combination of laboratory experiments, field measurements, and data science approaches to evaluate chromium(VI) production and metal transport from wildfires. Further, we examine the particle size distribution and chemistry. Laboratory studies reveal that chromium(VI) generation from soil particles responds nonlinearly with temperature, increasing up to ~600 °C. Using a unique natural (field) matrix, we show that fire severity, geologic substrate, and ecosystem type control the formation of hexavalent chromium. Hexavalent chromium concentrations were highest in soils derived from metal-rich geologies, and soil particulates from severely burned areas exhibited 6.5-fold greater concentrations of the toxin than from unburned soil. Hexavalent chromium persists in particulates composing smoke and post-fire dust, which presents concern for respiratory exposure of local and distal communities. The fine particulate matter can transport many hundreds of kilometers, with metals often being most concentrated on moderate air quality days. Importantly, toxic metal particulates have a lasting impact on ecosystem recovery, impacting soil biogeochemical processes for years post-fire.