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Toxic Ash: Unraveling the Impact of Vegetation Burning on Hexavalent Chromium Generation in Fire-Affected Soils

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Many more regions across the globe are realizing the effects of extended fire seasons on air quality, even when fires are hundreds of miles away. Increased frequency and intensity of wildfires in natural landscapes can catalyze soil chemical changes and in many cases can contribute to the release of toxins. One such geogenic toxin is hexavalent chromium, or Cr(VI). Trivalent chromium, a relatively immobile and non-toxic compound in soils, can be oxidized to its carcinogenic form during fires and persist in soils for weeks to months post-fire. Additionally, plants uptake metals from soils and when combusted could also transform into harmful ash that is easily wind-disperable and inhalable. However, it is difficult to assess contaminant transformation in post-fire soils as Cr(VI) can derive from both soils and aboveground vegetation burning and the wind-disperable post-fire ash contain a composite of soil and ash derived inorganic compounds. This study compares Cr(VI) generation in aboveground biomass of chaparral and grasslands grown in low- and high-metal content soils at a range of fire intensities. Twelve plant species were collected from the Stanford's Jasper Ridge Biological Preserve from chert (low metal) and serpentine (high metal) derived soils. Grasses were burned at 200, 400, and 600°C for 30 min and chaparral vegetation was burned at 400, 600, and 800°C for 1 hour in a muffle furnace to produce ash. Soils were also burned separately at a range of temperatures (100-800°C) and durations (5 min - 2 hr). Toxicity of the vegetation ash and the fine-particle fraction of the burned and unburned soils was estimated using simulated lung fluid extractions and Cr(VI) concentrations were estimated using diphenylcarbazide via UV-Vis spectroscopy. Cr(VI) was only detected in vegetation burned at moderate and high severity and contributed between 49-95% of the total Cr measured in ash. These data were compared to field observations of soil-ash mixtures burned through prescribed pile-burning at Jasper Ridge of similar vegetation types. Overall, our findings suggest that aboveground biomass does significantly contribute to Cr(VI) generation and low-severity burning scenarios may prevent Cr(VI) exposure.