Impacts of high magnitude wildfire on volcanic (lava tube) cave water chemistry.
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Introduction: Wildfires of high magnitude are known to cause complete destruction of surface vegetation, soil sterilization, alteration in physical, chemical and hydraulic properties of soils (Ebel et al., 2022), however, the post-fire effects on subsurface environments such as vadose zones, shallow aquifers, and caves are understudied. Caldwell Fire 2020 and Antelope Fire 2021 in northern California has likely affected 97% area of Lava Beds National Monument (California, USA) that protects numerous volcanic (lava tube) caves. These caves provide shelter for diverse groups of microorganisms, invertebrates, mammals (bats), host a variety of speleothems, and, therefore, are an important ecosystem. Meteoric water entering into the caves via cave openings, cave overburden and surface soils and sediments chemically interacts and provides nutrients for the growth of cave microbes. In this study, we aim to understand the impacts of high magnitude wildfires on the cave water chemistry by analyzing water samples from six caves from burned area at Lava Beds (collected in December 2021), a control cave, and comparing these data with pre-fire data (August 2017-2019) from these caves (Lavoie et al., 2017; Kulkarni et al., 2022; Ford et al. in prep.).

Methods: Caves from unburnt, partially burnt, and completely burnt areas of Lava Beds (total 6 caves) were selected to provide variability in surface cover, cave depths, proximity from the fire, and availability of pre-fire data. A total of 70 cave water samples from six caves after 4-, 9-, and 13-months post-fire were collected. A total of 22 surface soils from directly above the caves were also collected to perform a soil-water leaching experiment. All the samples were preserved in the dark at 4°C until analysis. The pH, temperature, and specific conductance were measured in water samples immediately upon collection using a HACH Pocket Pro+ Tester. Major inorganic anions and cations were measured using Dionex Integion and Aquion Ion Chromatography system. The concentrations of major and trace elements were measured using inductively coupled plasma mass spectrometry (ICP-MS, Agilent ICP-MS 7500cx). The DOC concentrations in water samples, measured as non-purgeable organic carbon (NPOC) and TDN concentrations were measured by thermic oxidation using Shimadzu TOC/TN Analyzer. Characterization of dissolved organic matter was done by measuring UV-Vis absorbance (240 nm to 450 nm) and fluorescence (300 nm to 600 nm) using Horiba Aqualog Benchtop fluorometer.

Results and Discussion: Pre-fire water chemistry was characterized by pH 7.76±0.25, specific conductance 76±16 µS/cm, concentrations of Na+, K+, Ca2+, Mg2+, Cl-, NO3-, and SO42- as 7±2, 1.2±0.2, 1.7±0.8, 1±0.4, 4±0.4, 4±2.5, and 2±0.3 mg/L respectively. Post-fire water chemistry in the same cave showed pH 6.55±1.17, specific conductance 82±21 µS/cm, and concentrations of the same ions as 3±1.7, 1.1±1.2, 5.7±3.3, 2.1±0.8, 0.6±0.3, 10±6.5, and 1.1±1 mg/L respectively. These results suggested that in post-fire samples there was a decrease in pH, concentrations of monovalent ions (Na+ and Cl-), and an increase in Ca2+ and NO3- concentrations. Similar chemical responses in surface waters have been recorded along with nutrient and cation trends in many other post-fire conditions under different water management programs as stated in Paul et al. 2022. Water leaching experiments with soils collected from above the respective caves showed that the soil specific conductivity decreased from 117±1.4 µS/cm to 20±0.1 µS/cm. On the contrary, soil from unburnt areas showed only a slight decrease in conductivity from 20.7±3.1 to 16.8±0.6 µS/cm. Further analyses to characterize changes in ionic composition and soil organic matter post-fire is currently underway.

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References: