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Interactions Between Geogenic Pollutants and Hydrological Patterns in Two Adjacent Mountain Watersheds Threatening Water Security of an Andean Metropolitan Area

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Geogenic pollutants in mountain headwaters play a major role in controlling water security in arid and semiarid watersheds, especially in mining areas during drought conditions. This work discusses the hydrological and hydrochemical interactions found at the upper Mapocho and upper Maipo watersheds, two surface drinking water sources for the metropolitan area of Santiago, Chile. While the Río Blanco-Los Bronces porphyry copper formation -one of the largest known copper reserves in the world- controls the hydrochemistry of the upper Mapocho waterhsed, the upper Maipo watershed is characterized by smaller mining operations, hydropower development, urban and agricultural land use, and influence from sedimentary and hydrothermal features.

The analysis of publicly available hydrochemical datasets as well as field sampling helped to identify the drivers of the concentrations of geogenic pollutants in these watersheds. Seasonal changes in stream discharge are largely controlled by snow and glacier melting in both watersheds, which alarmingly reveal the effects and threats of climate change. The dynamics of pH, suspended solids, and copper speciation (pH: 4-8; Cu: 1-10 mg/L) is controlled by acid drainage neutralization reactions and the mixing ratio of streams at confluences in the upper Mapocho Watershed. The seasonal and long-term trends of major ions (notably sulphate and chloride) and suspended solids in the upper Maipo Watershed pose major challenges to the protection and management of drinking water sources as well as the effectiveness and retrofitting of drinking water treatment plants. The "megadrought" affecting Central Chile over the past decade (2010-2020) has likely triggered shifts in river hydrochemistry through impacts on snowmelt, erosion, pollutant transport, and surface-groundwater interactions.

Integrated models and monitoring that capture the complex interactions between geochemical and hydrological drivers of river hydrochemistry are needed to guide public policy and decision making towards water security. These models should serve as common ground to face critical decisions in these and many other Andean watersheds, like the assessment of current and future mining and hydropower projects, restoration and use of green infrastructure, projecting water treatment needs, and setting environmental water quality standards and pollutant load limits.